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Case-Specific Report in *O'Haver v. Anesthesia Associates of Kansas City, P.C., et al.*, May 2, 2022

Dr. J.P. Abraham

I have previously submitted four reports in the Bair Hugger litigation; one on June 1, 2017 in the MDL; one in the case of *Louis Gareis v. 3M* on December 18, 2017; one in the *Axline v. 3M* case in September 2018; and one in *Trombley v. 3M* on February 15, 2019. I rely on and incorporate those reports for my opinions in the O'Haver case (with the exception of any content that related solely to case-specific features of the *Gareis, Axline,* and *Trombley* cases). There are also inevitable flow disturbances caused by movement of staff which occurs during a surgery that will affect the airflow within the room. In this report, I expand on the opinions I expressed in my earlier reports with respect to specific conditions in the operating room where Ms. O'Haver's 2016 left-knee replacement surgery took place that pertain to airflow.

My opinions are based on my education, training, and experience with airflow systems and computational fluid dynamics, as well as my review of the scientific literature. I also rely on the experiments I performed and calculations I completed in an actual operating room, as described in my MDL report. I reserve the right to supplement this case-specific report if I receive additional information relevant to my opinions and anticipated trial testimony in this case.

1. SUMMARY OF OPINIONS

It is my opinion that the FAW used on Ms. O'Haver (BH model 750) did not cause an infection. It is further my opinion that Plaintiff's expert is incorrect in his opinions, and the simulations he contracted to a third party are not relevant to the surgery on Ms. O'Haver. I will discuss these opinions in more detail in the following.

I base my opinions on my experience, education, and training in this field. I have nearly three decades of work in the thermal sciences (heat and fluid flow). I have produced well over 400 publications and presentations to the scientific community and my work is heavily cited by my peers. In 2021 alone, for example, my research was cited by my peers approximately 1300 times.

To elaborate on the opinions I disclosed in my earlier reports and testimony, and in addition to those opinions, I express the following:

1. As I have stated previously, there is no evidence that the Bair Hugger disrupts downward airflow, brings pathogens to a surgical site, or is otherwise capable of causing or contributing to surgical infections, and I have found no evidence that the Bair Hugger caused or contributed to Ms. O'Haver's development of a surgical site infection following her surgery.
2. There are many ways that airflow is disturbed in an operating room, such as the movements of the surgeons and staff, opening and closing of doors, traffic in and out of the room, location and type of surgical lamps, equipment that generates heat and air motion, equipment that impedes airflow from the ceiling supply vents, the locations of room inlet and exhaust vents, temperature differences between an OR and the adjacent

rooms, the type of ventilation system, and breathing by the surgical staff, among many others. Plaintiff's expert Dr. Elghobashi did not account for any of these disturbances in the calculations that he outsourced to a third party. Thus, to the extent any of Plaintiff's experts intend to offer opinions about the cause of Ms. O'Haver's infection based on the work that Dr. Elghobashi outsourced to a third party, those opinions lack a scientifically valid premise.

3. In the work contracted by Plaintiff's expert, Dr. Elghobashi, no account was made of bacteria shed by staff. This is particularly problematic because bacteria shed by staff can be shed directly above the surgical site and would easily fall into the surgical site because of gravity. As I will discuss below, bacteria shed by staff is a major concern, but was completely neglected by Dr. Elghobashi.
4. Dr. Elghobashi did not attempt to adjust his outsourced CFD simulations to reflect the operating room where Ms. O'Haver's surgery took place. He did not correct his simulation to incorporate the number and position of the inlet vents, the position and operation of the exhaust vents, the operating room flowrate, the shape and dimensions of the room, the details of the ceiling vents and fans, or the equipment within it. He also did not account for any movement of staff, changes to the number and positioning of staff, breathing of staff, opening or closing of doors, traffic within the OR, breathing by the surgical staff, or temperature and pressure differences between the OR and adjoining spaces. Every one of these items is known to disrupt and modify airflow patterns. Again, to the extent any of Plaintiff's experts intend to offer opinions about the cause of Ms. O'Haver's infection based on Dr. Elghobashi or the calculations that he outsourced, those opinions are based on an irrelevant set of assumptions. It is my understanding that Dr. Elghobashi has not even visited the operating room where Ms. O'Haver's surgery took place. Furthermore, he has not included any details of the room in his declaration.
5. Independent researchers have published computational and experimental results that support the opinions I derived from my own investigation. My work shows that the BH device is unable to penetrate the clean-air curtain that forms around the surgical site. These articles do not support Dr. Elghobashi's opinions, or any opinions that Plaintiff's experts intend to offer based on the simulations that Dr. Elghobashi contracted from a third party.
6. In the intervening approximately six years since this litigation started, Dr. Elghobashi has not responded to my criticisms; nor has he taken steps to address the shortcomings in his work.

2. OPERATING ROOM AIRFLOW IS DISTURBED BY MYRIAD FACTORS THAT ARE NOT ACCOUNTED FOR IN PLAINTIFF'S COMPUTATIONAL ANALYSES

There are many ways that airflow can be disturbed in an operating room like the one where Ms. O'Haver's surgery took place. Chief among these are:

1. The position and movement of surgical lamps and other equipment
2. The number, position, and movement of the treating physicians and staff
3. The number and positioning of vents which distribute filtered air over the operating table
4. Other obstructions, including surgeons and staff

5. Devices and equipment that generate heat and exhaust air
6. The positioning of the exhaust vents that draw air from the room, and whether they are powered or passive
7. The presence and location of other vents (supply or exhaust) that exist in the room and their position relative to each other
8. Opening and closing of doors, and traffic in and out of the room
9. Bacteria shed by the surgical staff, directly above the surgery, that can fall into the surgical site and lead to infection
10. Breathing of the surgical team

Plaintiff's CFD models ignore all of these factors. As a result, their models cannot predict airflow trajectories, particle paths, or other airflow features that would have been present during Ms. O'Haver's surgery, nor do those simulations address known sources of infection (such as bacteria shed by the surgical team or the patient, or breathing by the surgical staff).

Published literature demonstrates the importance of each of the above considerations to the constantly changing dynamics of operating room airflow.

The position and movement of obstructions

Among the research supporting this point, [1] was an experimental study that used three different methods to visualize airflow. The methods were Schlieren photography, bubble-generation, and smoke visualization. The authors considered surgical lamps and staff as potential obstructions to the airflow. They found "*The importance however of obstructions such as operating lamps and personnel was shown*." The researchers of [1] used smoke visualization to show airflow patterns (as were used in my experiments). Also, [1] found that lamps can disrupt airflow for large distances (greater than 6 feet) from the lamp itself. [1] also reported that with respect to person movement, there was a "*disruption of flow caused by his obstruction and movement*." Consequently, the position and motion of surgical lights and personnel throughout the surgery are critical for predictive calculations. I agree with the conclusions from [1]. I also agree with [1] that experiments can be performed to show airflow patterns that do not require $2,000,000 and two months to complete and another month to analyze – an opinion of Dr. Elghobashi (Gareis trial transcript, page 896, lines 1-8).

More recently, [2] showed not only do lamps matter in determining airflow, but that numerical calculations must be validated. In this study, complementary CFD calculations and experiments were performed to assess the effect of various lamp sizes and shapes on airflow. The key finding was that "*the projected area of a lamp is a good indicator for the infection risk*." Consequently, the positioning and movement of lamps throughout the surgery are essential inputs for any calculation which seeks to be predictive. The researchers of [2] used the LES model in the software ANSYS for their calculations. The researchers concluded that particles can be treated as a gas, as was done in my calculations. The researchers also validated their calculations by comparing the results with airflow experiments. The authors of [2] used smoke to show airflow patterns, similar to the approach that was used in the experiments I will show later. I agree with the authors of [2] that the location and type of lamp are important in affecting airflow near the surgical site – an issue that was neglected in the simulation contracted by Dr. Elghobashi. I agree with the authors of [2] with respect to their experiments – contradicting the statements of Dr.

Elghobashi that experiments require $2,000,000 and months of duration (Gareis trial transcript, page 896, lines 1-8). I note that during his testimony, Dr. Elghobashi stated that "no one should enter in because the optical equipment has to be set up." To the extent Dr. Elghobashi is claiming an OR must be empty when experiments are set up or performed, or that the experiments would take two months to complete, he is demonstrably incorrect. In fact, instead of an empty OR, experiments should be performed in an OR with operating staff, with equipment, and in the presence of motion of personnel, equipment, and doors. Performing an experiment in a denuded OR would provide little or no information about airflow patterns that would occur in an occupied OR.

Other recent studies confirm these findings. For instance, [3] found that "*If a vertical laminar airflow ventilation system is utilized, obstacles such as the surgeons' heads and operating lamps become increasingly important. Currently many medical devices that disturb the unidirectional downward flow are installed above the operating area, which can reduce the effectiveness of the vertical laminar airflow ventilation. Moreover, the heat generated by medical devices and surgical team members has a remarkably negative effect on the vertical LAF system. There is a considerable stagnant area behind surgical lamps with large surface areas when they are interposed in the unidirectional down flow systems. This stagnant area may include a high bacteria concentration because it is usually close to the contamination source, such as a surgeon.*" It is noteworthy that the authors of [3] validated their calculations using experiments. Also, the authors of [3] used the calculation software ANSYS and they use streamlines to show airflow patterns. I agree with the authors of [3] that obstructions such as surgeons' bodies and lamps are important with respect to airflow. I also agree that ANSYS software and streamlines can be used to show flow patterns, and that heat generated in an OR is important to consider. I further agree with [3] that bacteria shed by a surgeon is important. I also agree with [3] that experimental validation is important. These are all things that were neglected in the simulations that were outsourced by Dr. Elghobashi. I also agree with the authors of [3] that experiments are not so time consuming and costly that they cannot be reasonably performed; in contrast to the opinion of Dr. Elghobashi.

Another study [4] confirmed the conclusions of [3]. There, the effect of objects like surgical lamps that are positioned above the operating table was shown to be important. It is again noteworthy that the authors of [4] performed their calculations using ANSYS RANS models and validated their calculations by comparing the results to experiments; I agree with the authors of [4] that ANSYS RANS can be used to calculate airflow. I agree with [4] that the positionings of objects, such as surgical lamps, are important.

Very recently, [5] provided even more evidence of the importance of the position, size, and movement of surgical lamps. These researchers stated that "*The most important source of airborne contamination in an OR is related to the infectious particles released from the surgical staff.*" To assess these particles, the researchers used the software program ANSYS (RANS model) to calculate the airflow patterns. They found that surgical lamps positioned above the operating table have a significant effect on the airflow. They conclude, "*When combined with a closed-shape lamp, laminar air flow results in more than 100 bacteria carrying particles per unit area that settle over the operating table in one hour.*" The authors of [5] validated their results with experiments, a step that I have performed as well. I also agree with the authors of [5] that it

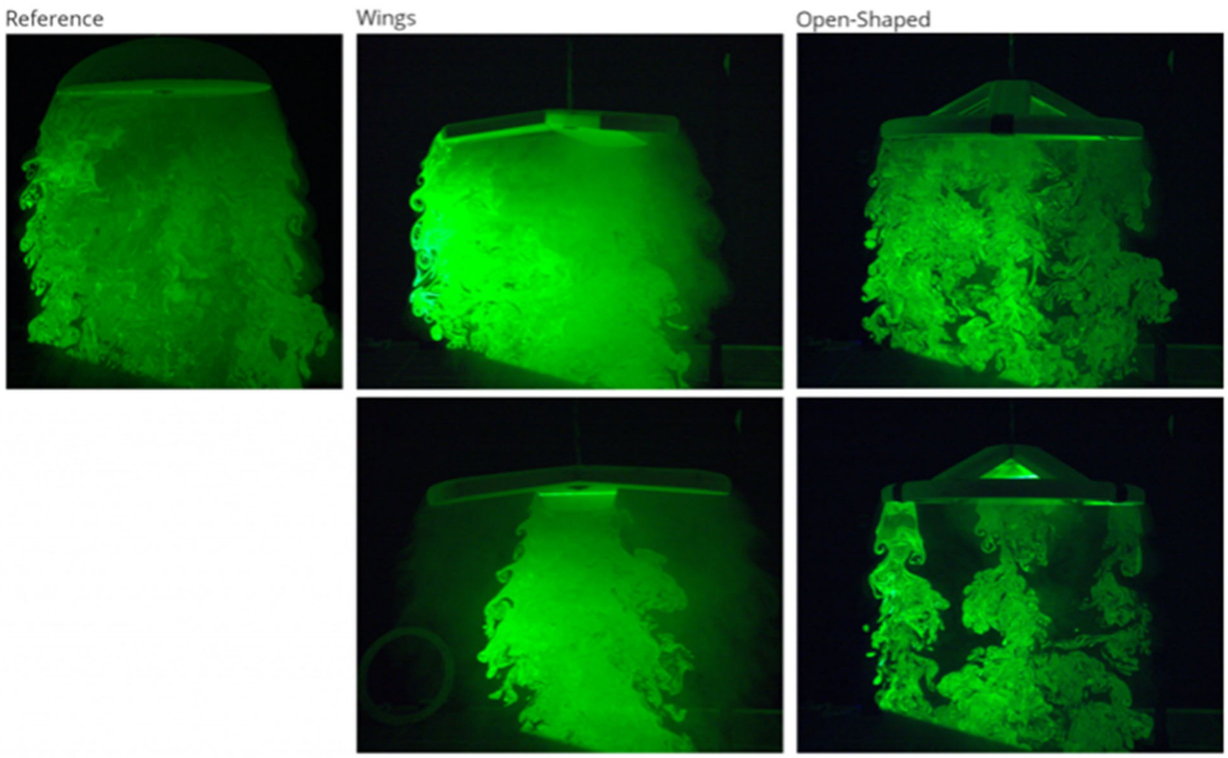
is important to include the bacteria shed by medical professionals. They use a shedding rate of 5 CFU/s for each person. Bacteria shedding from the surgical staff and the patient was completely ignored by Dr. Elghobashi and the calculations that he contracted out to a third party. I also agree with [5] that the position, size and movement of surgical lamps affect airflow patterns.

More research has confirmed the clear fact that surgical lights can impact airflow, and that accounting for the position and movement of surgical lights is essential for any airflow predictions. Using experiments, [6] found that when no surgical lights were used, downward airflow from the ceiling passed unimpeded. However, if lights are placed above the surgical location, the downward unidirectional airflow is disrupted and air can recirculate in the surgical field. They also conclude that a light above the surgical site reduced the airflow system's ability to clear the air. The authors write "*Surgical lights have a significantly negative effect on laminar airflow. Lights should be positioned as far away as practicable from the surgical field to limit this effect.*" Again, this study confirms the importance of the position and movement of lights. I agree with the authors of [6]; their work contradicts the opinions of Dr. Elghobashi. I also note that in [6], experiments were completed with reasonable effort. I agree with the authors of [6] that tracers can be used to show flow patterns in an OR.

Researchers in [7] used a thermal mannequin and surgical lamps in their experiments. They found that lamps did impact the airflow above the operating table. They also found that thermal plumes from the warm patient may cause higher velocities over the operating table. The authors write "*This study showed a complex airflow distribution in the operating microenvironment of a lying patient. The air distribution may change significantly under various conditions involving the presence of different heat sources, including the surgical lamps, the patient, surgical staff and various monitors in the orthopedic OR. These heat sources will generate various forms of thermal plume, which have great potential to hinder clean airflow to the surgical site…. Using the lamps at horizontal positions may block clean airflow from the LAF system. It is therefore suggested that the placement of lamps should be carefully considered before an operation to ensure that the clean supply air reaches the surgical site…. In addition, the presence of surgical staff may further disrupt the clean air distribution in proximity to a patient in ORs.*" The authors also report that "*the downward airflow from the laminar airflow system <u>varies in each case with different surgical arrangement</u>, such as the position of the operating lamp*." This research shows that no two rooms or two surgeries are alike. These researchers also used air velocity measurements (streamlines) to quantify flow in the room. I agree with the authors of [7] that each case is different and that the surgical arrangement is important. I agree with [7] that heat sources, lamps, surgical staff, and other equipment will affect airflow. I also agree with the authors of [7] that experiments can be performed with a reasonable expenditure of time and resources. Our view (the view of [7] and myself) contrasts with that of Dr. Elghobashi who testified that experiments are prohibitively expensive and time consuming.

The same findings were confirmed by [8] who performed flow visualization experiments in a laminar-air-flow environment with mannequins that represented the patient and the staff. They found that lights significantly disrupt the airflow. I also note that again, experiments were performed without unreasonable costs or duration, contrary to the testimony of Dr. Elghobashi. I agree with the authors of [8] that obstructions can significantly disrupt airflow in the room – contrary to the opinion of Dr. Elghobashi.

While overhead lights are necessary for performing joint replacement surgery, it is important to recognize the role they can play in disrupting ceiling airflow and circulating particles shed by surgical staff. Visual evidence of these obstructions is provided in Fig. 1 (and listed videos) by the Hermann-Rietschel-Institut (HRI) [9], and provided online by the German Federal Ministry for Economic Affairs and Energy (https://blogs.tu-berlin.de/hri_op-luft/2019/01/04/closer-look-on-lamp-shapes/).



Video 1: Flow Vizualisation of recirculation area under different shaped luminaires

Fig. 1 – The effect of surgical lights on downward laminar airflow systems [9]

What is evident from these many studies is that the positioning and movement of obstructions, and equipment and objects that generate heat, have profound effects on operating room airflow. Any predictive calculation must account for those effects. Insofar as the Plaintiffs' simulations do not account for the positioning of surgical lamps or their changes during Ms. O'Haver's surgery, the position and motion of the staff, the presence of heat sources, and airflow obstructions above and near the surgical site, they cannot be used to predict particle paths during that surgery.

These studies also demonstrate that ANSYS is widely used by independent researchers to calculate air flow in operating rooms. They further reinforce the importance of validating calculations with experiments. Finally, this research shows that no two rooms or two surgeries

are alike. The airflow is different in each situation. I agree with these conclusions; and these conclusions contradict the opinions expressed by Dr. Elghobashi.

The number, position, movement of surgical staff, door openings, and traffic in and out of the operating room

Movement of the surgeons and staff are also important. In [10], a CFD model was used with a RANS algorithm and Boussinesq equation (as in my calculations). In the CFD model, particles were simulated to be released from the surfaces of the staff/surgeons. The researchers found that the simple action of bending by a surgeon can increase particles at the surgical site 250 fold. The study, carried out in a vertical-flow ultra-clean airstream, envisioned the surgeon bending forward and then back up to vertical. The authors validated the CFD calculations by comparison to an experiment. This study shows that surgeon motion, even a single bend, not only disrupts airflow patterns, but it can also increase airborne particle concentrations. This demonstrates that ignoring surgeon motion makes Plaintiffs' CFD calculations non-predictive. I agree with the authors of [10] that surgeon movement can be incorporated into a study and that movement is important. This contrasts with Dr. Elghobashi whose contracted simulation completely neglected any surgeon or staff motion. I further agree with [10] that bacteria released by the surgical staff is important; they report 1000 CFUs per minute for each person. This contrasts with Dr. Elghobashi who has totally neglected bacteria release by people in the simulation he contracted out to a third party. I also agree with [10] on the importance of validation for these types of studies. This contrasts with Dr. Elghobashi who did not validate the calculations that he outsourced – he performed no experiments within the O'Haver OR, within any OR, or within any room whatsoever.

The researchers in [10] also report "*We found that the air supply velocity and the medical lamp position can strongly influence the dispersion of airborne infectious particles and hence the infection risk,*" providing added support to the opinions discussed above. This further confirms that the location and movement of surgical lights and surgical staff must be incorporated into any predictive model. I agree with the authors of [10] that air supply velocity and lamp positions can strongly influence the dispersion of infectious particles. This is in contrast to the calculations outsourced by Dr. Elghobashi to a third party where these issues were completely ignored.

The work in [10] was confirmed by [11] who used CFD methods to study airflow. In the CFD model, simulated particles were released from the simulated surgical team. The authors showed that the position of the surgical staff can have dramatic effects on the concentration of bacteria-carrying particles. In particular, bending surgical staff significantly increased the concentration of simulated particles at the surgical site. The authors write "*when the staff member bent over the operating or instrument tables, the promising performance of the ultraclean-zoned airflow screen was drastically reduced*." I agree with these authors. The study [11] used ANSYS RANS for the calculations and validated the numerical model using experiments. The authors of [11] also incorporated bacteria shedding by surgical team members. I agree with [11] that shedding needs to be included in a predictive calculation. This view contrasts with the calculations outsourced by Dr. Elghobashi that completely neglected bacterial shedding. I also agree with [11] that the position and motion of staff is important, in contrast to Dr. Elghobashi who completely ignored these issues. I also agree with [11] that ANSYS RANS can provide accurate air flow information. I further agree with [11] on the importance of validation.

In [12], results of another study on the effect of staff movement were provided. There, smoke visualization studies and computational investigations were performed. The study included a laminar air flow surgical room and the movement of a staff member within the room. When staff moved, they found "*the influence on the contaminant concentration is very significant and a substantial increase in the bacteria level around the operating table is found. Around the operating table the bacteria level increased with approximately 25 cfu/m^3*." This study shows that motion of staff cannot be neglected in any attempt to model conditions that may have been present during Ms. O'Haver's surgery. The calculations in [12] relied upon vectors/streamlines to indicate flow patterns; no separate particulate trajectory calculations were performed. In this regard, it is a worst-case calculation and is the same method I adopted in my analysis. I note that [12] included the motion of surgical staff in their study. I agree with [12] that motion is important to include in a predictive calculation. This is in contrast with the work that Dr. Elghobashi outsourced to a third party – there, no motion was included. I also agree with [12] that airflow experiments can be performed with reasonable expenditures of time and resources.

In [13], a computer prediction of airflow in an operating room was accomplished using the ANSYS RANS program. The calculations were validated with experimental data and the analysis corresponded to a unidirectional downward airflow operating room. It was shown that motion of the surgical staff can disrupt air flow near the patient. The calculations were based on an actual operating room that is in service. The authors report that motion "*progressing towards the operating table would cause small and light particles to be released from the person, and this could contaminate the surgical area*." The authors also state that "*lateral human movement created a significant effect on the airflow patterns inside the OR."* I agree with [13]. This study also shows that motion of the surgical staff cannot be neglected in any effort to model OR airflow conditions. This study further shows that numerical models should be validated by experimentation. I agree. It also demonstrates the capacity of ANSYS to calculate these airflows. Furthermore, this study confirms the use of airflow patterns (streamlines) to show paths of particles in the room.

Other studies, such as [14], have shown that the number and position of the surgical staff matter. This study, which also used ANSYS software and the Boussinesq model, was validated by experiments (using temperature and velocity measurements). The study used ceiling mounting unidirectional airflow and assumed a shedding rate of 4 CFU/s for each staff member. The chosen fluid model was the $\kappa-\varepsilon$ RNG approach, executed by the ANSYS software. The conclusion from the study was that as the number of staff increases from 4 to 10, the concentration of simulated particles increases at the operating table and at instrument tables. This study shows that it is critical to account for the number and positioning of the staff during the surgery when creating a predictive model. This study also shows that ANSYS can be used for calculating airflow in an operating room, that my buoyancy equation is accepted by the research community, and that CFD models should be validated with experiments. This study also includes bacteria shedding by staff members. I agree with [14] that predictions need to incorporate bacteria that is shed by staff, in contrast to the work outsourced by Dr. Elghobashi that included no bacteria shedding. I also agree with [14] that the location and motion of equipment can disturb the airflow – in contrast to the work outsourced by Dr. Elghobashi that ignored all motions within the OR and did not account for the correct placement of any of the equipment, or

even the correct size or shape of the room, location of vents, etc. The authors of [14] write "*Increasing the number of personnel within the OR disrupts the ventilation airflow pattern and causes enhanced contamination risk in the area of an open wound.*" I agree.

So too in [15], the researchers report that an increase in the movement and activity in an operating room corresponds to an increase in counts of airborne microorganisms. Such activity was not accounted for in the computational studies associated with the present litigation. The authors write "*Disruption of the intended airflow, caused by traffic entering and exiting the OR with multiple openings of the OR door during the surgical procedure is associated with increased risk of wound contamination and possible SSI*." I agree.

These conclusions were also found experimentally in [16] where the effect of movement and presence of the patient and staff had "*by far the greatest effect on numbers (of bacteria)*." I agree; the presence and movement of patient and staff are important and should not be ignored.

In addition to positioning of airflow obstructions, and positioning and movement of surgical staff, the opening and closings of doors affect airflow within the room. While I have not been provided an exact count of door openings and closings during Ms. O'Haver's procedure, *any* entries or exits during the surgery would disrupt airflow. Moreover, entries and exits *before* the surgery could introduce shed particles into sterile areas and onto sterile instruments.

Among the research on this subject is that of [17]. That research team took airborne bacteria samples during 81 orthopedic surgeries, mainly total-joint arthroplasties. They found that "*Laminar Air Flow does reduce the contamination due to more door openings, but does not abolish it*." They also report that "*if the doors are opened at all, the expected number of CFUs increases by 69.3%*". The authors report that unidirectional airflow decreases the CFU by less than 40%. They also report "*The majority of the risk of contamination was introduced with the first opening*." The effects were seen both inside and outside the unidirectional flow area. The effect of door openings on the operating room is two-fold. First, there is a direct disturbance of the air in the room caused by the door opening. Second, door openings often coincide with persons entering the room and bringing contamination. The authors write "*Door opening creates turbulence by diminishing the pressure gradient between two spaces. Turbulent air follows a chaotic, non-laminar pattern which might lead to faster spread of airborne bacteria or aerosolized and dust borne contaminants, to the surgical field. We also report a concordant increase in microbial counts with the frequency of door openings*." I agree with the conclusions of this study. I note that in the simulations outsourced by Dr. Elghobashi, the difference in pressure levels between the OR and the adjoining rooms was completely neglected.

This finding, of the impact of door openings on airflow, was confirmed by [18]. That study used a numerical calculation technique called Large Eddy Simulation to calculate airflow patterns in a room when a door opens and a person enters into the room. The CFD analysis was compared with experiments to validate the calculations. Furthermore, the calculations were completed using ANSYS. The experiments and calculations show that air from outside the room is pushed very far into the isolation room following the door opening and entrance of a mannequin. Visual evidence from [18] is shown in the image below. Smoke is used to visualize the air brought from one room into the adjacent room. The researchers in [18] used a gas instead of particle transport

in their calculations of potentially unclean airflow. This was the approach I also used. I agree with the conclusions of this study. In particular, I agree that both personnel motion and doors both negatively influence the air flow patterns in a room and present a risk to a patient.

camcorder shot CFD LES

Fig 7. Smoke experiment in the anteroom side. Experimental smoke visualization as compared with simulated smoke drawn by the method of stacked contour maps. This figure is one frame of S4 Video. Again, a certain height interval alone is being lit.

Fig. 2 – smoke images showing unclean air entering into a room [18] and being carried with moving personnel

Similar findings were reported in [19] where experiments were carried out with both hinged and sliding doors, and a mannequin. Those researchers used a smoke generator to show airflow patterns – the same technique that was used in my experiments. These experiments contradict Dr. Elghobashi's trial testimony that such experiments require $2,000,000 and months of time. The researchers found that in both cases, unclean air was brought far into a room with the entry of staff – air motion accompanies any motion of personnel within a room. Again, smoke was used to show the amount of air brought from one room into the adjacent room. In Fig. 3, there are a series of four images. In (A), the door has not yet opened. In (B), the door has opened outwards (a hinged door swinging to the right of the image). In (C), the person has moved into the room, carrying with them unclean air. In (D), the person is in the room and the door has closed. The unclean air has filled the clean space and extended well past the person (who is now standing still). These effects (doors and motion) were completely ignored by Dr. Elghobashi and the calculations that he outsourced to a third party. I agree with the authors of [19] that airflow experiments can be performed using smoke tracers; I also agree with the authors of [19] that opening of doors and movement of people cause airflow disturbances that must be considered in a predictive analysis.

The direction of the swinging door does not stop the airflow. In the same study [19], images were taken from the other side of the door. Those images are shown in Fig. 4. Again, unclean air is easily able to enter a clean room and contaminate it. Also evident is that personnel motion causes tremendous airflow and can bring unclean air to a surgical site.

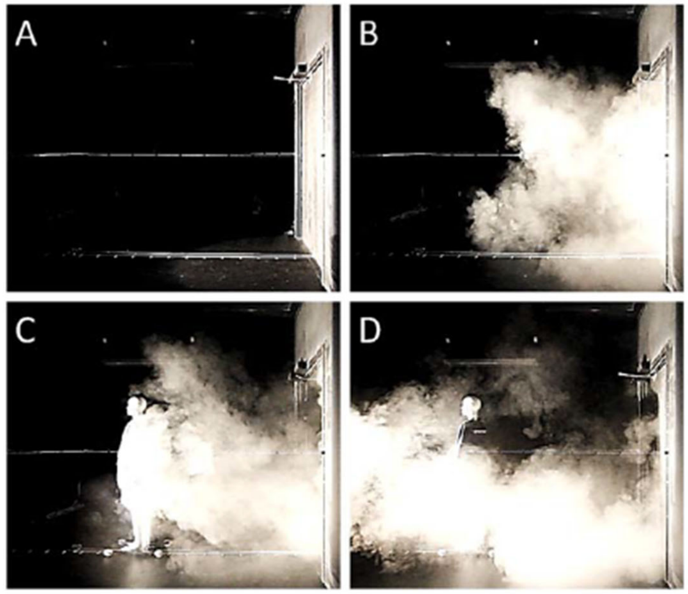


Figure 2. Smoke visualization (anteroom side-view) of the airflow patterns across the doorway generated by the single hinged door and the manikin passage.

Fig. 3 – Four images showing unclean air pass into a clean room as a mannequin moves through a hinged door [19].

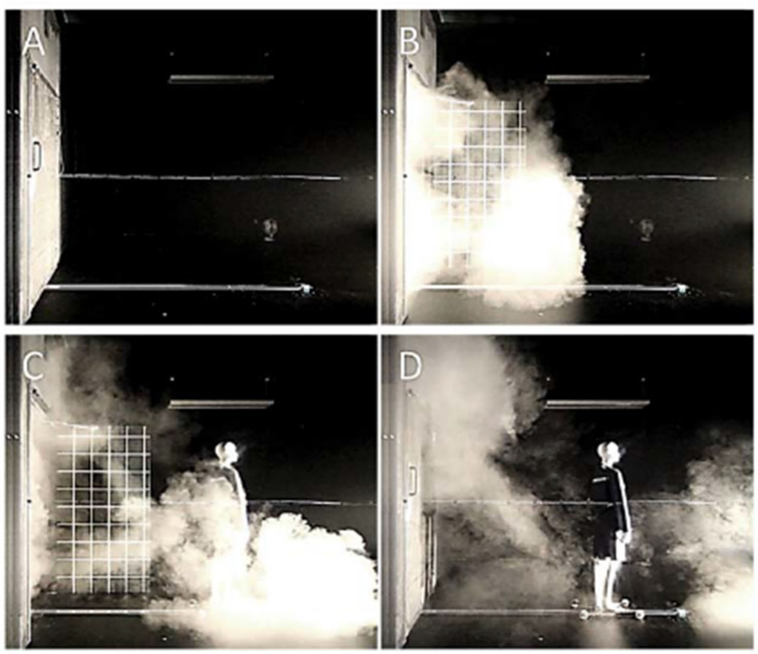


Figure 4. Smoke visualization (isolation room side-view) of the airflow patterns across the doorway generated by the single hinged door and the manikin passage.

Fig. 4 – Four images showing unclean air pass into a clean room as a mannequin moves through a hinged door [19].

It has been thought that sliding doors might mitigate this concern. But as shown in [19] with Fig. 5, unclean air is able to easily pass into a clean room when a sliding door is used. The report of [19] also further confirms that when there is personnel motion, that motion causes tremendous air disturbances; air is carried with the moving person. These disturbances can bring unclean air to a surgical site. I agree with the findings of [19].

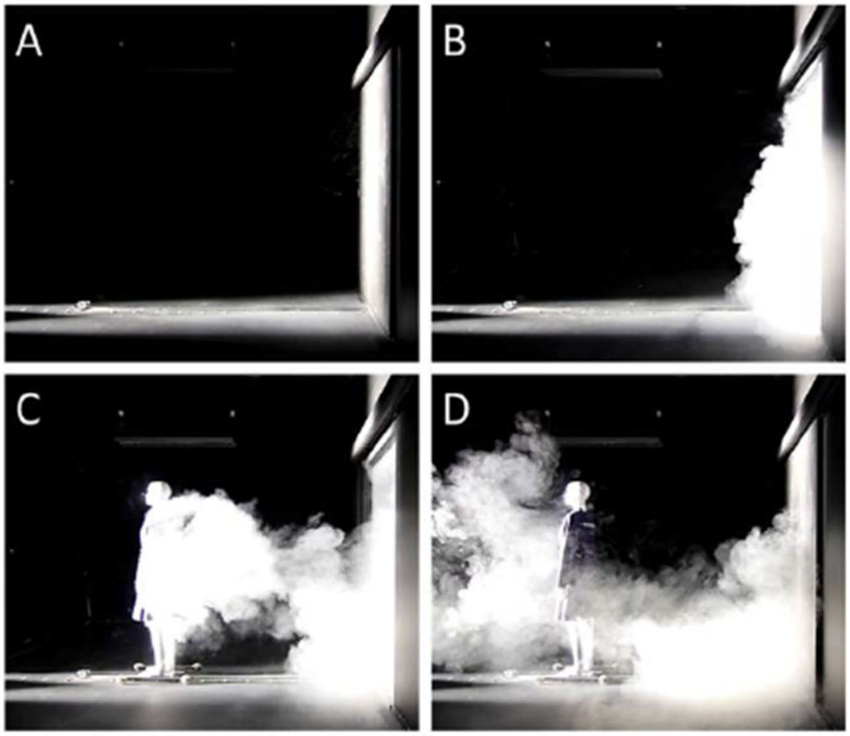


Figure 6. Smoke visualization (anteroom side-view) of the airflow patterns across the doorway generated by the sliding door and the manikin passage.

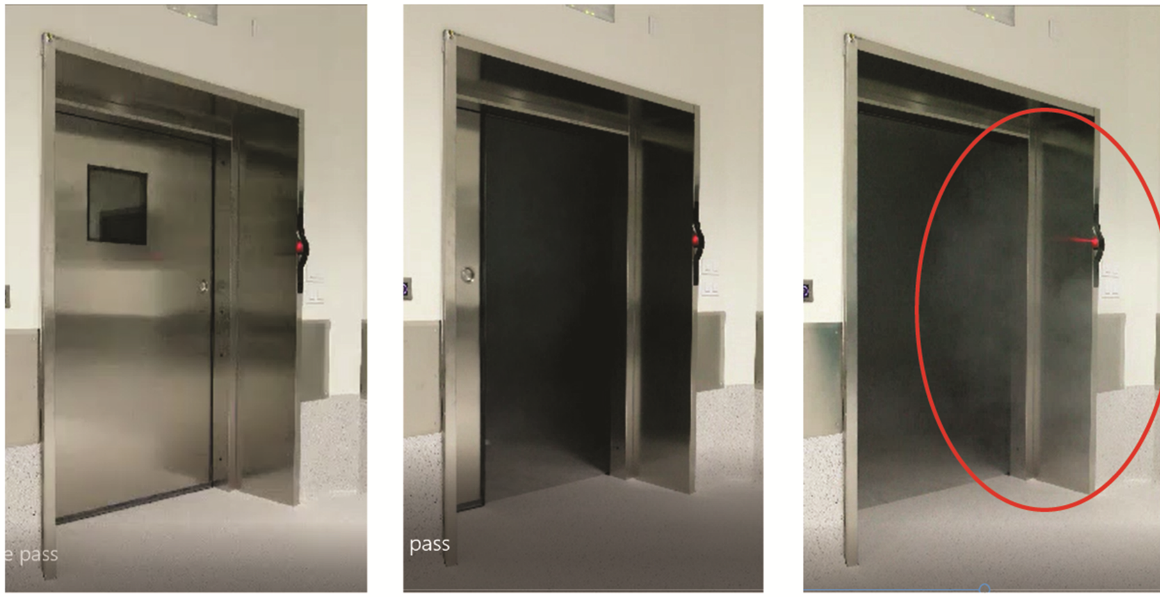
Fig. 5 – Four images showing unclean air pass into a clean room as a mannequin moves through a sliding door [19].

The motions and door openings shown in Figs. 3-5 were ignored by the Plaintiff's experts.

The importance of door openings was also confirmed in [20]. There, a sliding door to a pressurized laminar air flow operating room was opened. These doors are designed to minimize any outside air that may enter into the room. The experiment showed that when the door opens and a person enters the room, they bring with them a large volume of outside air. The experiment is shown in the attached video images below.

The first image is prior to the sliding door opening. The second image shows the door nearly open. In the third image, air from outside the room is seen to be entering into the operating room, even though the operating room is positively pressurized. In the fourth and fifth images, a staff member is walking through the doorway. It is seen that they bring with them a large volume of outside air. In the final image, the door is closing and outside air is still seen within the operating room. I agree with [20] that smoke can be used to show airflow patterns – such experiments do

not require $2,000,000 in equipment of months of duration, as stated by Dr. Elghobashi. In addition, I agree that opening of doors and movement of personnel contaminates otherwise clean air. I also agree with [20] that door openings and personnel motion are separate issues that on their own disrupt airflow. Both issues should be considered in a predictive simulation.

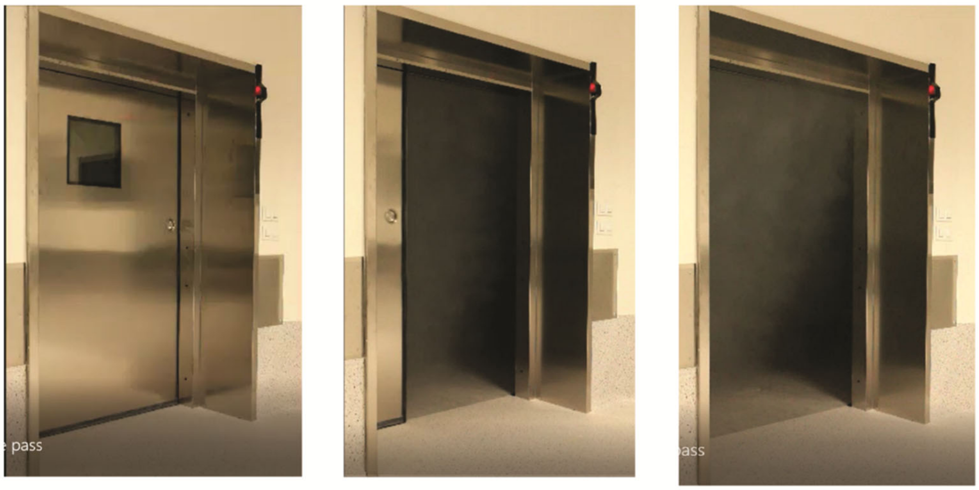


Sliding Door Closed | Door Almost Open | Smoke Entering Room

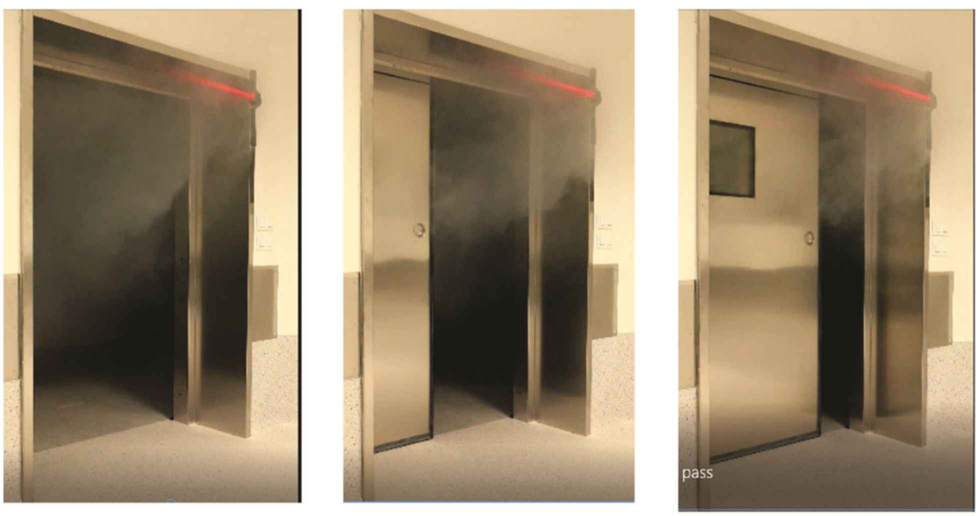
Staff Entering | Staff Brings Smoke | Smoke Within Room and Door Closing

Fig 6 – Still images from video showing unclean air entering into an OR [20]

Even with no people entering, just the process of opening a sliding door causes outside air to enter into the operating room. As shown in the sequence of six images below, despite the use of a sliding door (designed to minimize incursion of outside air) and despite a pressurized operating room (also designed to repel outside air), even when no staff pass through the doorway, outside air enters the room. The intrusion of air would be even more significant with swinging doors. If proper pressure were not maintained with the operating room, or if a staff member entered through the doorway (which may have occurred during Ms. O'Haver's surgery). In the simulations that Dr. Elghobashi contracted out, pressure levels in the OR compared to the neighboring rooms were completely neglected.



Sliding Door Closed | Door Almost Open | Smoke Outside Room



Outside Air Entering | Smoke Within Room and Door Closing | Smoke Within Room and Door Closing

Fig. 7 – Still images from video showing unclean air entering into an OR [20]

Further confirmation of the importance of operating room door openings was provided in [21] where door openings were often able to defeat the positive pressure of an operating room during joint arthroplasty.

Another study, that used ANSYS software and validated the work with experiments, confirmed that even when the rooms are pressurized to mitigate the passage of outside air, it still is able to enter a room [22]. Images from that study are shown in Figure 8. There, the "clean" room is on the right and the "unclean" space is the left. The colors indicate the concentration of outside air. There are a series of 6 images. In the top two images, a door is opened. In the second row of images, a simulated person (indicated by the white block) enters the room, carrying contaminants from the outside space. In the last row, the door closes and the contaminants remain in the room, surrounding the person that entered. The research of [22] used the same software and particle tracking approach that I used in my general causation calculations. I agree with the authors of [22] that opening of doors and movement of personnel will contaminate an otherwise clean room. These findings support studies that I have already discussed related to doors and motion. I agree with their conclusions.

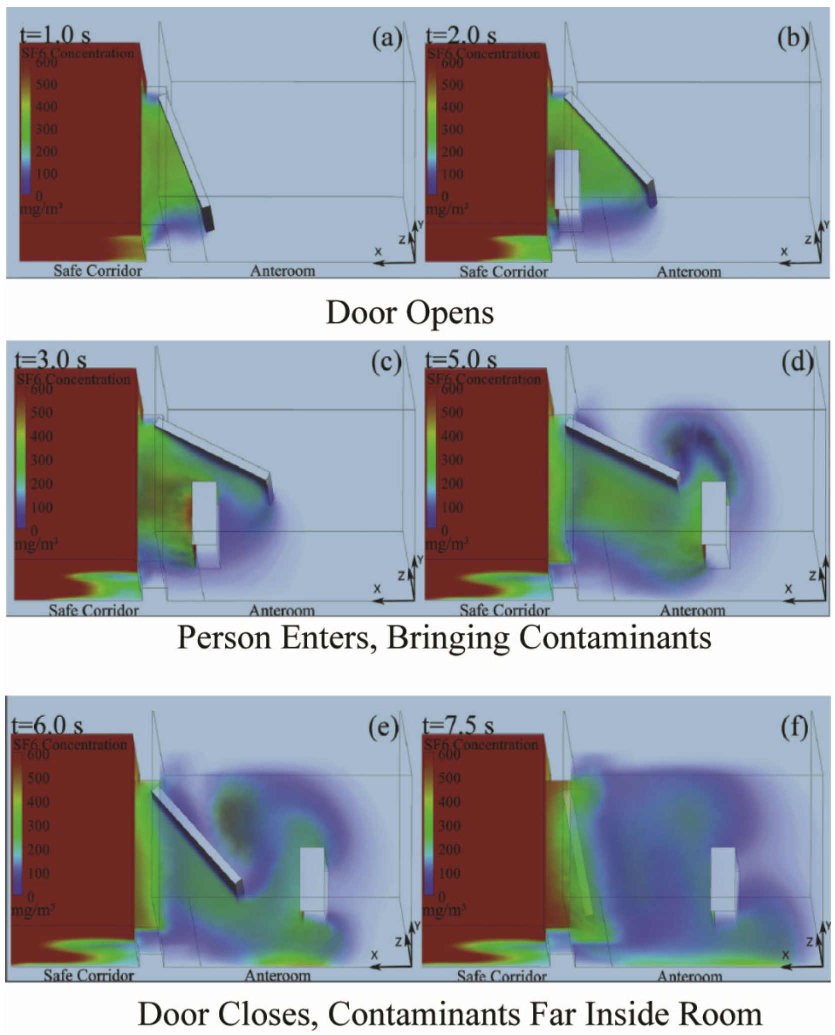


Fig. 8 – Contaminants entering a room when a door opens (from [22]).

These findings show that even for systems specifically designed to prevent outside air intrusion, it happens every time the operating room door is opened. Because of their obvious impact on operating room airflow, door openings and personnel traffic must be included in any attempt to

predict through CFD the movement of airstreams and particles during Ms. O'Haver's surgery. Because the Plaintiff's CFD models do not do this, they cannot predict the airflow patterns, pathways, or positions of airborne particles that may have been present during Ms. O'Haver's surgery. What is also clear is that other researchers have performed such studies (simulations and experiments). Incorporating motion, positioning of obstructions, the presence or absence of door openings, etc. is routinely carried out in the scientific literature.

In [23], experiments were carried out on dust and airborne bacteria levels in a ceiling vented HEPA filtered OR with floor exit vents. 82 microbial samples were made with both active and passive sampling techniques. Airborne dust was measured with a light-scattering dust sensor. During the surgeries, logs were made of the number of door openings, length of surgery, use of various medical devices, etc. The researchers found that door openings were negatively associated with dust particles but were positively associated with increases in bacteria levels. They write "*As expected, air microbial contamination was mainly related to human activity. Independently of the plate position and sampling method (active/passive) bacterial counts were positively associated with door-opening frequency, taken as an index of staff and visitor movement to and from the operating room*." I agree with the authors of [23] that opening of doors and movement of personnel contaminate an otherwise clean room.

These results reinforce those of [24]. There, ANSYS RANS was used to calculate the effect human walking has on the air in a room. The authors state *"Our findings show that the human walking disturbs the local velocity field with wake formation."* The authors' calculations, which were validated by experiments, show a wake extended from a person as they pass through a room, similar to the wakes found in [18-21]. I agree with the authors of [24] that ANSYS RANS can be used for these types of calculations. In addition, I agree that motion of personnel within a room can cause contamination of otherwise clean spaces. I also agree with the authors of [24] that experiments can be performed with reasonable effort and cost.

Yet another study using flow visualization showed that a moving person carried with them a wake of air. That wake continues past the person even after they have stopped moving [25]. Fig. 9, which is taken from their study, shows a trail of air is brought into a room by a walking mannequin. As the mannequin moves from right to left, a traveling mass of air is brought with them. When the mannequin stops, the unclean air passes forward of the body and makes any contamination worse. The unclean air in front of the body persists even after the person has stopped moving.

Starting to Move

Stopped Movement

Continuing Movement

Stationary

Continuing Movement

Stationary

Fig. 9 – Photographs of an experiment showing air brought along with the motion of a human [25].

A separate set of images from another experiment confirms this fact – humans bring air with them as they walk and carry outside air into an OR. Any predictions of airflow must include such motion. The annotations within the images of Fig. 10 are from the authors of that scientific study. I agree with the authors of [25] that motion of personnel will cause contamination of otherwise clean spaces.

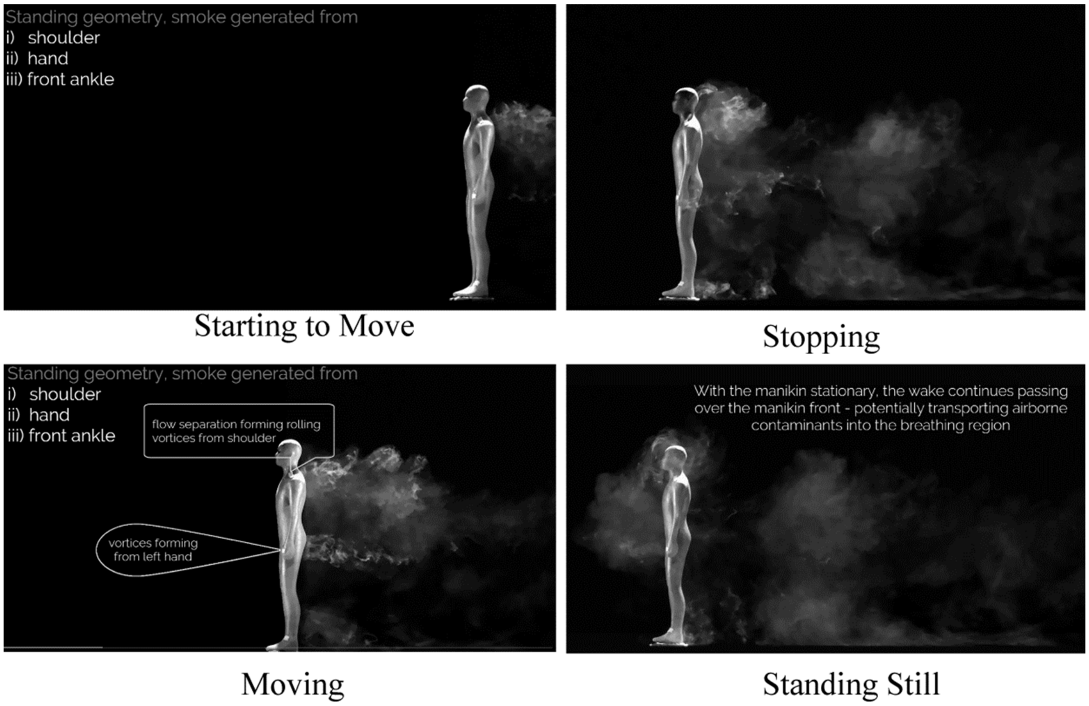


Fig. 10 – An experiment showing air brought along with the motion of a human [25].

In [26], a validated calculation using ANSYS RANS was performed on the effect of door openings on bacteria within a positive pressure OR. It was found that even when pressurized, "*the ventilation system fails to maintain the required positive-pressure, which results in the dispersion of infectious particles into the OR.*" The authors also state, "*door-opening disturbs the air flow field and could result in contaminant failure.*" They report "*This study indicates a significant relationship between OR door-openings and room pressure as well as contaminant level. Results show that the airflow movement from the doorway considerably affects the control of airborne contaminant diffusion. Door-opening led to a breakdown in isolation conditions and caused dispersion of infectious air into the OR.*" In this study, the authors demonstrated that door openings are important, even when there is no motion of any personnel. I agree with the authors of [26], that door openings are important air disturbances that should be incorporated into an analysis. This is an aspect that was totally absent from the calculations that Dr. Elghobashi outsourced to a third party.

The effects of door openings have also been demonstrated in other research. For instance, [27] performed experiments in positive pressure operating rooms and found that measured air particle counts increase when doors are opened.

Also, [28] found that the number of door openings in the operating room and surgery duration were significantly associated with increased bacteria in the operating room. Within the "ultraclean" zone, the number of staff members was significantly associated with increased bacteria load, and results were presented for 20 door openings and greater.

Yet another study [29] was performed that also used ANSYS RANS to study airflow in operating rooms. The study matched an actual operating room (St. James University Hospital,

Leeds). The inlet was positioned above the surgical site. Two surgeons, a patient, the operating table and three instrument tables were included in the analysis. Boundary conditions were based on experimental measurements in the operating room and on flow visualization experiments. The calculation was validated by measurements of air speed in the operating room. An anemometer was used to collect air velocity data. In the calculations, pressure differences between the room and an open door were varied from equal pressures to an excessive pressure level (20 Pa). Streamlines were used to track airflow patterns. The researchers found that when the pressure difference between the OR and the surroundings decreases, the ventilation system is not able to provide its protective effect. The authors of [29] used streamlines to show the effectiveness of the protective barrier., and I agree with their method and with their use of experimentation to validate calculations. I also agree with the authors of [29] that $2,000,000 in cost and two months of time is not necessary to perform validation experiments. This contradicts testimony of Dr. Elghobashi that such costs and durations are necessary. In fact, anemometers, such as those used in [29], and pressure gauges can be purchased for well under $1000.

Another recent study [30] on the impact of door opening considered a process wherein a sliding door opens and closes over an 18-second period. The opening requires 7 seconds, the door is held open for four seconds, and the closing requires 7 seconds. The operating room is pressurized and different room temperatures are studied. It was found that even when the room is pressurized, unclean airflow from adjacent spaces will enter. The calculations used CFD and were validated with experimentation. The authors find that any temperature difference between the operating room and the adjoining room creates a large vortex which brings fluid very far into the surgical room. Even temperature differences as small as 1 degree can defeat the positive pressure of the operating room. These findings occur without any motion of staff which is known to make infiltration worse. Results from [30] are shown in Figs. 11 and 12. Neither Dr. Elghobashi nor the calculations that he outsourced included the temperature difference between the OR and the adjacent room – even though the temperature difference influences the airflow patterns and the intrusion of unclean air into a sterile room. Including this information in the calculations is a trivial exercise and could have been included; however, it was not. I agree with the authors of [20] that door openings matter and that room temperatures matter. These findings contradict the opinions of Dr. Elghobashi.

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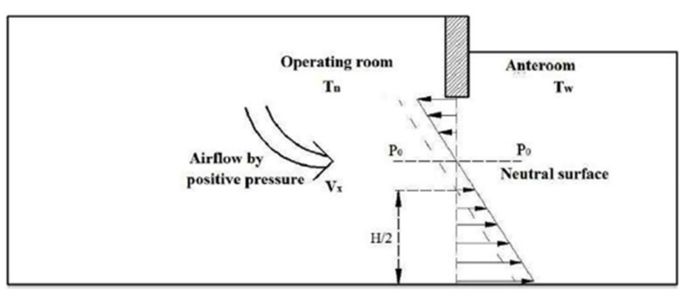


Fig. 2. Schematic diagram of airflow exchange between operating room and anteroom with comprehensive effect of temperature difference and pressure difference.

Fig. 11 – Image from [30] showing how outside air can enter an operating room, even when positively pressured.

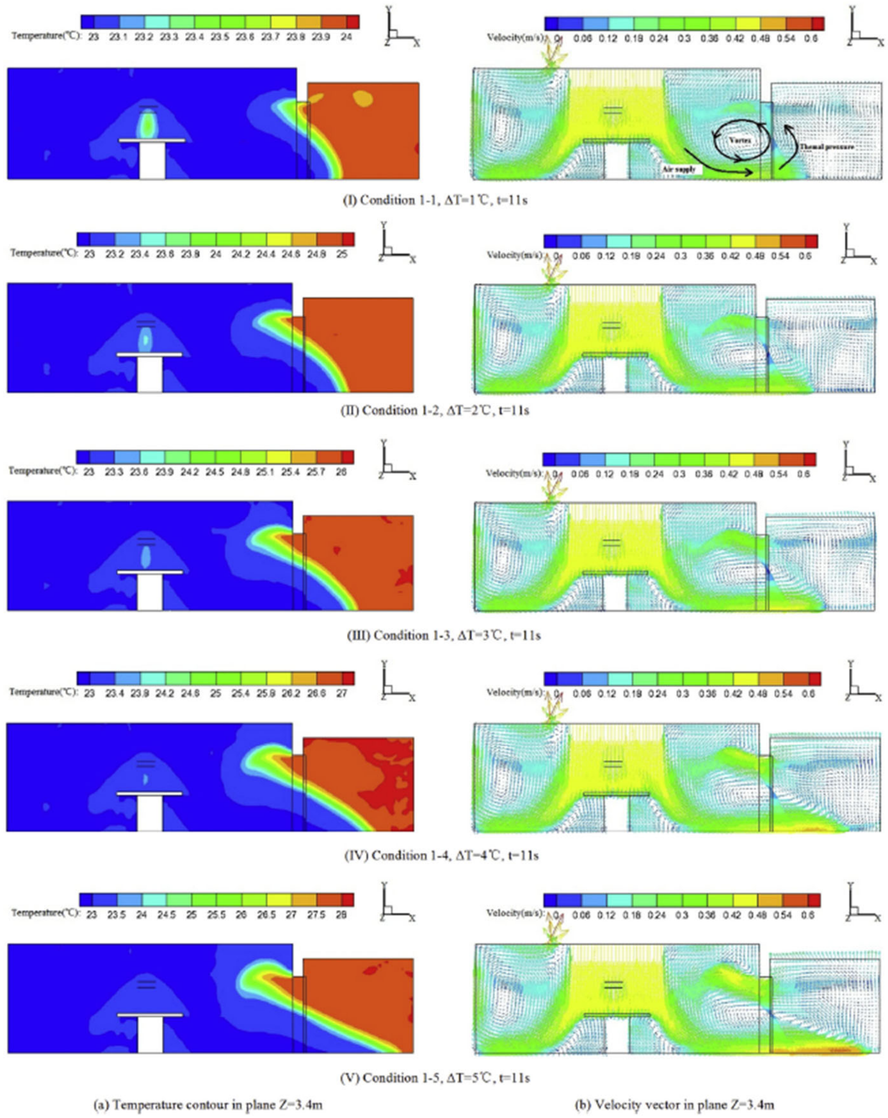


Fig. 12 – Image from [30] showing outside (red) air entering an operating room even when positively pressured. The air flows out of the room at the floor and into the room at the ceiling.

This background shows that every operation is different. These studies demonstrate not only the significant impacts of door openings on operating room airflow, but also that ANSYS software is a reliable tool to calculate airflow in this setting. Dr. Elghobashi did not account for door openings and traffic, and did not use ANSYS. Nor did he account for any of the other factors that affect air flow, as I have already discussed in detail.

This literature also demonstrates the importance of experimental validation for airflow calculations. All but one of the independent research studies performed a validation experiment. The one study that did not validate was a self-described "pilot study." The lack of validation is a

major shortcoming in the work that Dr. Elghobashi outsourced to a third party. As demonstrated by this literature review, experiments of airflow can routinely be performed without $2,000,000 and two months in duration – as testified to by Dr. Elghobashi.

Surgeon breathing is another potential vector for pathogens to enter the sterile field. As with shedding by the surgical team, breathing is particularly important because it introduces pathogens to the space above the surgical site where they tend to fall downwards (due to gravity) toward the patient. Visual evidence of breathing is provided by the Hermann-Rietschel-Institut (HRI) [9], and provided online by the German Federal Ministry for Economic Affairs and Energy (https://blogs.tu-berlin.de/hri_op-luft/2019/01/04/closer-look-on-lamp-shapes/).

Fig. 13 - Photographs showing airflow before and during surgeon breathing [9]

This body of research demonstrates the necessity of accounting for movement and positioning of the surgical team throughout the surgical procedure for any attempt to build a predictive model of operating room airflow. According to the literature, staff motion and position are predominant influences on airflow and particle dispersion. This body of research also shows that ANSYS is a widely accepted program used for calculating airflow in an operating room and that my methodology is accepted within the scientific community. It is used extensively by researchers for this purpose. Finally, the body of research highlights the necessity of validating numerical calculations using experiments. For all of these reasons, any opinions offered by Plaintiff's experts based on the calculations outsourced by Dr. Elghobashi are fundamentally flawed. Their CFD models cannot describe the movement of squame particles shed by surgical staff during Ms. O'Haver's surgery.

Summary statement on motion, doors, and obstructions, etc.
Taken together, this body of research clearly demonstrates the importance of factors within the operating room that must be considered, including the positions and movement of the staff; the specific details of the room, including, but not limited to, the position, number, and type of the vents; the location and movement of surgical lights; the occurrence of door openings/closings; pressure or temperature in the OR compared to the adjacent rooms; breathing of the staff; bacterial shedding of the staff; and the presence of medical equipment that can affect flow. Insofar as these cause major effects on the airflow and can impact air quality within the operating

room, they must be considered throughout the surgery by any calculation which claims to be predictive.

As I have stated previously, in my CFD calculations for the Model 750 and Model 505, I did not account for door openings, movements of staff, changes to the position and movement of the surgical lights, among many other factors shown to impact airflow in the literature discussed above. That is because the purpose of my calculations was not to predict the dispersion of airborne particles in a particular plaintiff's case, but rather to determine whether the Bair Hugger disrupted the downward flow of air over the surgical table under the conditions set forth in my model, setting aside the countless airflow disruptions from other sources that would occur during a typical surgery. Under the conditions of my calculations, air from beneath the operating table or from the Bair Hugger itself does not intrude into the clean-air curtain that surrounds the surgical site. These conclusions are verified by physical experiments which took place in the same operating room that is modeled in my calculations. They are also supported by independent researchers (for instance [32]) who concluded "*Airflow caused by forced air warming is well countered by downward laminar airflow from the ceiling*."

In addition to the above discussion of blockages, movement, surgical lamps, doors, heat generating devices above the surgical site, and presence, number and position of staff, so too does the HVAC system impact the airflow within the operating room. Among the details that must be accounted for in any predictive calculation are the number and location of the inlet vents (in the ceiling); the flowrate through the ventilation ducts; the number and position of the exhaust vents which allow air to exit the room, and the operating mode of the exhaust vents (passive or active); the size of the room; the shape of the room; and the actual ventilation flowrate that enters the room [33]. That study used ANSYS RANS, along with the Boussinesq buoyancy model (as did I) to calculate airflow patterns. They also compared their calculations with experiments, as did I. It should also be noted, based on the work of Memarzadeh, that excessive velocity from ceiling ducts could overwhelm the patient's protective surgical plume and impinge particles on the surgical wound.

A summary of the scientific literature discussed above, along with the studies performed by Plaintiff's and Defendants' experts, is provided by the following table. Of the more than 30 studies listed here, they strongly attest to the importance of validation. They also strongly support the importance of the position and movement of people, blockages, opening/closing of doors, shape and size of the room, positioning of the inlet and outlet vents, bacterial shedding by staff and patient, breathing by staff and patient, temperature difference between the operating room and the adjoining rooms, and the pressure difference between the operating room and the adjoining room. The outlier amongst these 34 studies is the one contracted by Dr. Elghobashi from a third party.

Ref.	Method or Software Used	Issue Considered	Findings	Experiments or Validation?
[1]	Experiments	Air Obstructions	The position and movement of obstructions, such as lamps and personnel, matter.	Yes

[2]	ANSYS LES	Air Obstructions	The position and movement of obstructions, such as lamps, matter.	Yes
[3]	ANSYS	Air Obstructions	The position and movement of obstructions, such as lamps and personnel, matter.	Yes
[4]	ANSYS RANS	Air Obstructions	The position and movement of obstructions, such as lamps and personnel, matter.	Yes
[5]	ANSYS RANS	Air Obstructions	The position and movement of obstructions, such as lamps and personnel, matter.	Yes
[6]	Experiments	Air Obstructions	The position and movement of obstructions, such as lamps, matters	Yes
[7]	Experiments	Air Obstructions	The position and movement of obstructions, such as lamps and personnel, matter.	Yes
[8]	Experiments	Air obstructions	The position of lamps has a major effect on airflow in surgical region.	Yes
[9]	Experiments	Air obstructions and surgeons	Obstructions and surgeons disrupt airflow and bring pathogens to the surgical site.	Yes
[10]	RANS CFD	Staff Movement	Staff movement changes the airflow in room.	Yes
[11]	ANSYS RANS	Staff Movement	Staff movement changes the airflow in room.	Yes
[12]	RANS CFD	Staff Movement	Staff movement changes the airflow in room.	No ("pilot study")
[13]	ANSYS RANS	Staff Movement	Staff movement changes the airflow in room.	Yes
[14]	ANSYS RANS	Staff Movement	The number, position, and movement of staff matter.	Yes
[16]	Experimental	Staff Movement	The number, position, and movement of staff matter.	Yes
[17]	Experimental	Door Openings	Door openings disrupt airflow within room, and bring unclean air into room.	Yes
[18]	ANSYS	Door Openings	Door openings disrupt airflow within room, and bring unclean air into room.	Yes
[19]	Experimental	Door Openings	Door openings disrupt airflow within room, and bring unclean air into room.	Yes
[20]	Experimental	Door Openings	Door openings disrupt airflow within room, and bring unclean air into room.	Yes

[21]	Experimental	Door Openings	Door openings disrupt pressure within room.	Yes
[22]	ANSYS	Door Openings	Door openings disrupt airflow within room, and bring unclean air into room.	Yes
[23]	Experimental	Door Openings	Door openings disrupt airflow within room, and bring unclean air into room.	Yes
[24]	ANSYS	Staff Movement	Staff movement changes the airflow in room.	Yes
[25]	Experimental	Staff Movement	Staff movement changes the airflow in room.	Yes
[26]	ANSYS RANS	Door Openings	Opening doors disturbs the airflow in an operating room.	Yes
[27]	Experimental	Door Openings	Opening doors disturbs the airflow in an operating room.	Yes
[28]	Experimental	Door Openings	Door opening and number of staff affects clean air in OR.	Yes
[29]	ANSYS	Door openings and positive pressure effects	Opening of doors and reduction of pressure causes contamination at surgery site.	Yes
[30]	RANS CFD	Door openings and temperature differences	Any temperature differences between an OR and the adjacent rooms cause unclean air infiltration.	Yes
[31]	Plaintiff's Proprietary CFD	No motion, no doors, no changes to staff, movement of equipment, other blockages above surgical site, different inlet and exhaust vents from actual OR. FAW does disrupt downward air flow.		**No**
[32]	Experimental	Effect of FAW	FAW does not disrupt OR airflow.	Yes
[33]	ANSYS RANS	Position of Vents	Position of outlet vents matters.	Yes
[34]	ANSYS	No motion, no doors, no changes to staff, movement of equipment, other blockages above surgical site, different inlet and exhaust vents from actual OR. FAW does not disrupt downward air flow.		Yes

3. SURGICAL ROOM DETAILS

Obstacles, heat-generating equipment, venting blockages, venting locations, etc.
As discussed here, the details of the OR matter, and will matter throughout an entire surgery. Some details that I have already discussed include the number, position, and movement of staff in the OR; the movement and positions of the surgical lights; the existence, position, and movement of any obstructing or heat-generating components; the opening of doors; the pressure and temperature within the OR and the adjoining rooms; the exact position of inlet vents and the exact position of exhaust vents; the operating mode of the exhaust vents; the flowrate of filtered

air into the room; the shape and size of the OR; bacteria shedding by staff and patient; and breathing by staff and patient. As noted, insofar as none of the simulations carried out by any of Plaintiff's experts has accounted for these factors, they are not predictive.

Incorrect dimensions of the room, surgical equipment, and vents
Finally, the shape and size of the room, and the location of both supply and exhaust vents all dictate the airflow patterns. Insofar as the Plaintiff's experts have not performed any calculations for the O'Haver OR, the calculations are not able to provide predictive information about what happened during a surgery there.

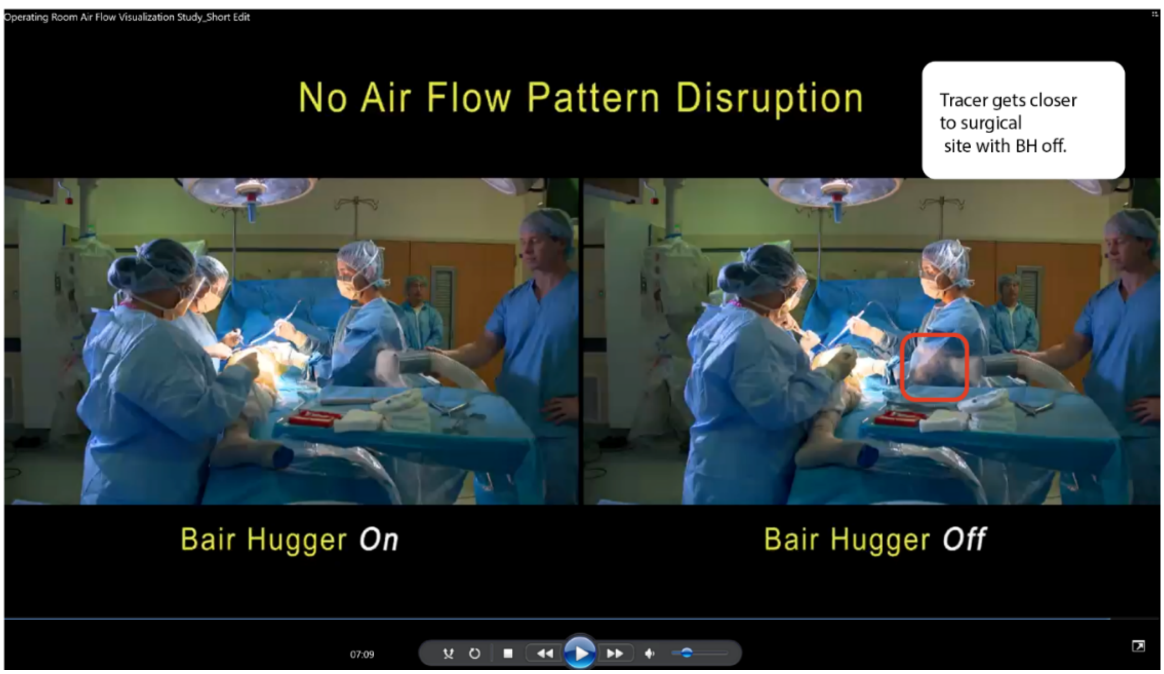
4. AIR FLOW EXPERIMENTS IN AN OPERATING ROOM

I was present at, and participated in, experiments carried out in an operating room with medical staff present during a mock joint replacement surgery. The mock surgery included a practicing medical team that prepared a patient and performed mock movements to simulate an actual surgery.

A flow visualizing device was used to reveal air flow patterns in the OR; videographic and photographic evidence was collected for surgical operations with and without the FAW device. It was found that the presence of FAW had no material impact on the air flow patterns within the OR. These experiments provide direct evidence that contradicts Plaintiff's expert.

The following image shows flow patterns near the operating table with a smoke tracer purposefully injected at the surgical site. The left image shows flow patterns with the BH turned on while the right image corresponds to the BH not on. There is no noticeable difference in the air flow patterns. I continue by providing other images of air flow tracers directed in various directions near the surgical table and positioned at various locations. In each case, side-by-side images show that the operation of the BH FAW device does not cause a disruption in the air flow patterns. These experiments contradict the simulation results that Dr. Elghobashi contracted out to a third party.

Left-hand image shows smoke purposefully directed to the surgical site with the BH on. The right-hand image is a corresponding photograph with the BH off. There are no appreciable differences in the flow patterns.



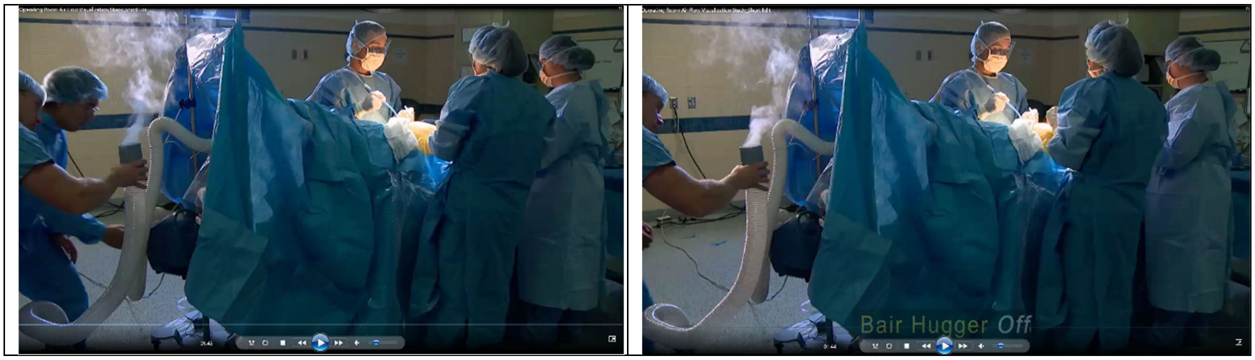
Left-hand image shows smoke purposefully directed to the surgical site with the BH on. The right-hand image is a corresponding photograph with the BH off. At this instant, the tracer gets much closer to the surgical site when the BH is not turned on.

Left-hand image shows smoke directed upwards near the surgical site with the BH on. The right-hand image is a corresponding photograph with the BH off. There are no appreciable differences in the flow patterns.

Left-hand image shows smoke directed perpendicular near the surgical site with the BH on. The right-hand image is a corresponding photograph with the BH off. There are no appreciable differences in the flow patterns.

Left-hand images show smoke directed upwards near the patient's head site with the BH on. The right-hand images are with the BH off. There are no appreciable differences in the flow patterns.

In order to show how movement can change airflow patterns, I have extracted a series of frames over a ~4 second duration during the flow visualization experiments. In those images, a person enters into the frame from the left and turns the BH device off. The person does not pass through the air-flow tracer. Rather, they are to the side of the tracer. Nevertheless, the loss of coherence of the air-flow tracer reveals the air disruption caused by even a simple motion. In fact, when the first image (upper left) is compared with the last image (lower right), the extent of the disruption is evident. The simulations that Dr. Elghobashi contracted to be performed by a third party did not account for any such motion.



A sequence of frames over approximately 4-second duration that shows movement causes air disturbances. Such disturbances were completely neglected by simulations contracted out by Dr. Elghobashi.

To supplement the experiments, I carried out calculations of air flow patterns in the same OR. My calculations showed that the downward flow of cold, filtered air from the ceiling shielded the surgical site from the intrusion of unclean air. I adopt the discussions previously provided in my prior reports. I also adopt my prior testimony that a calculation should be performed using the actual OR with the correct number of people, allowance of movement, inclusion of door openings and closings, movement and position of equipment, heat generated by equipment present in the room, the correct location of air duct vents, and the size and shape of the room. Without including these boundary conditions, a calculation will be in error – a fact admitted to by Dr. Elghobashi in his previous trial testimony (Gareis Trial Transcript, page 912, lines 3-9).

5. OTHER ERRORS IN DR. ELGHOBASHI OPINIONS

Here, I recite my earlier and unresponded-to criticisms of Dr. Elghobashi. It is noteworthy that Dr. Elghobashi admitted during trial testimony that these issues matter and changes to the simulation setup will affect the results (Gareis Trial Transcript, page 912, lines 3-9).

Despite this admission, he apparently has not undertaken the task of correcting these errors.

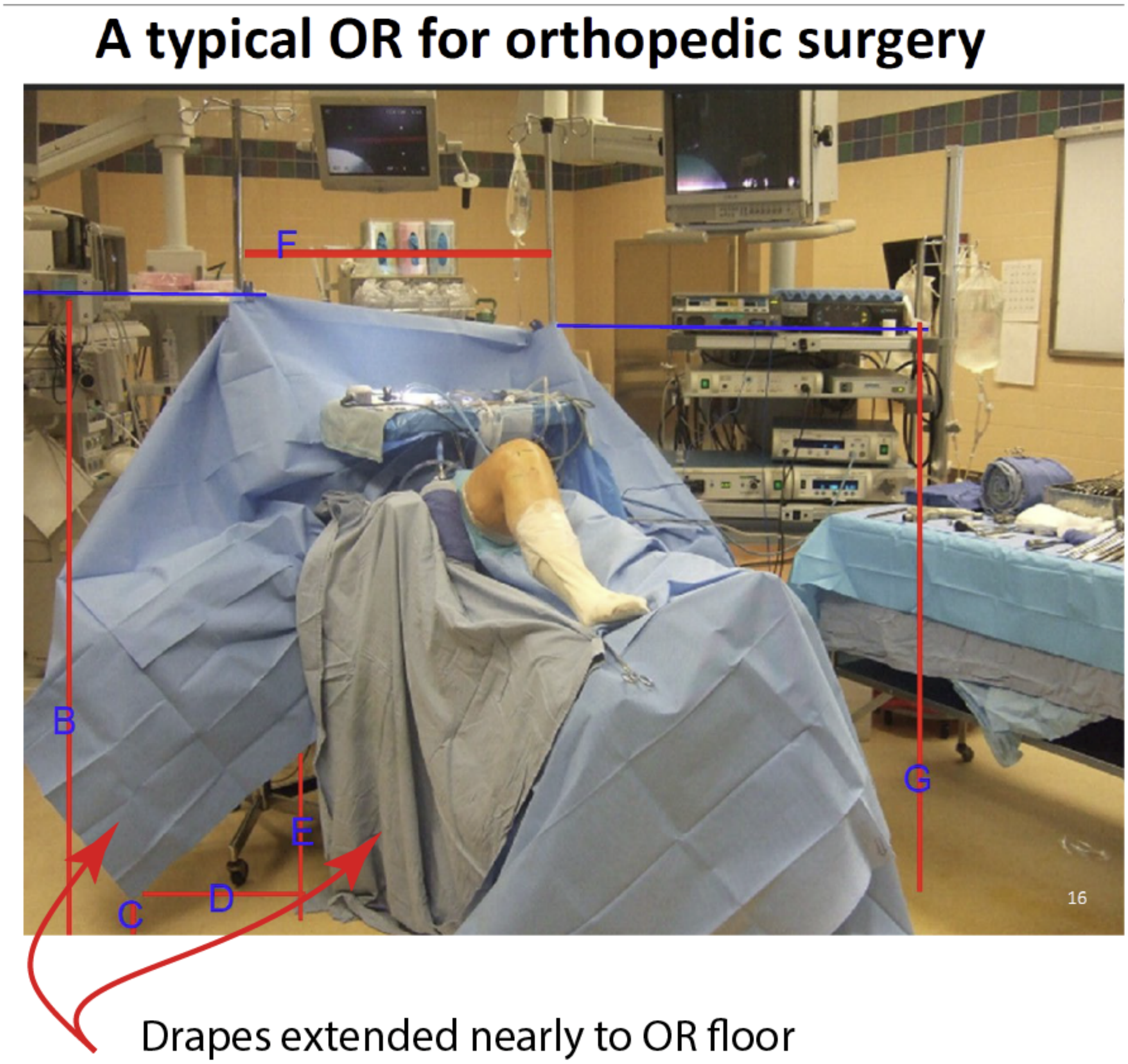
1. He performed no experiment to validate his model, and so his conclusions are unconfirmed and unreliable.
2. He does not clearly define how the Bair Hugger heated air enters the room. From the incomplete description given, it appears that he has made a serious error by allowing the heated air to emerge along a slot at the bottom edge of the drape. This assumption is in stark contrast to what occurs in the actual use of the Bair Hugger device, where heat from the blanket emanates primarily from the head and neck of the patient. Dr. Elghobashi's incorrect assumption invalidates his analysis.
3. He has removed a significant heat source – the surgical lights – from his analysis, despite defining it as part of his model.
4. He claims to present information along two precisely located planes that pass through the modeled room, but, in fact, his results do not correspond to his purported location.

5. His modeling of skin cells as spheres not only has a mathematical error but is also based on a faulty premise.
6. He incorrectly treats collisions as perfectly elastic (they are not) and then later contradicts himself.
7. His inlet vent conditions have two serious errors related to the incorrect duct assumptions and to the neglect of exit vanes.
8. Dr. Elghobashi made major errors with respect to the dimensions he used in his calculations.
9. Dr. Elghobashi mischaracterized the way the inflatable blanket rests atop a patient's arms. He presumed the inflatable blanket floats, unsupported in air. This is incorrect.
10. Dr. Elghobashi forgot, or neglected, buoyancy in major portions of the airflow.
11. Dr. Elghobashi made an error in a heat transfer calculation that I have identified.
12. Dr. Elghobashi still has not performed any calculations or experiments in an OR in which an infection took place. Dr. Elghobashi has also neglected to account for the correct number of treating clinical staff, movement of the staff, opening and closing of doors, the position of airflow obstructions such as lights and medical equipment, movement of people or equipment, the shape of the room, the location of inlet vents, the location of outlet vents, bacterial shedding by staff and patient, breathing by staff and patient, and others. That is, Dr. Elghobashi has neglected numerous critical factors in his analysis and has not performed an analysis of the actual O'Haver operating room.

The above-listed criticisms are still active, and surprisingly, Dr. Elghobashi appears to have taken no action to address these errors or even to respond to them.

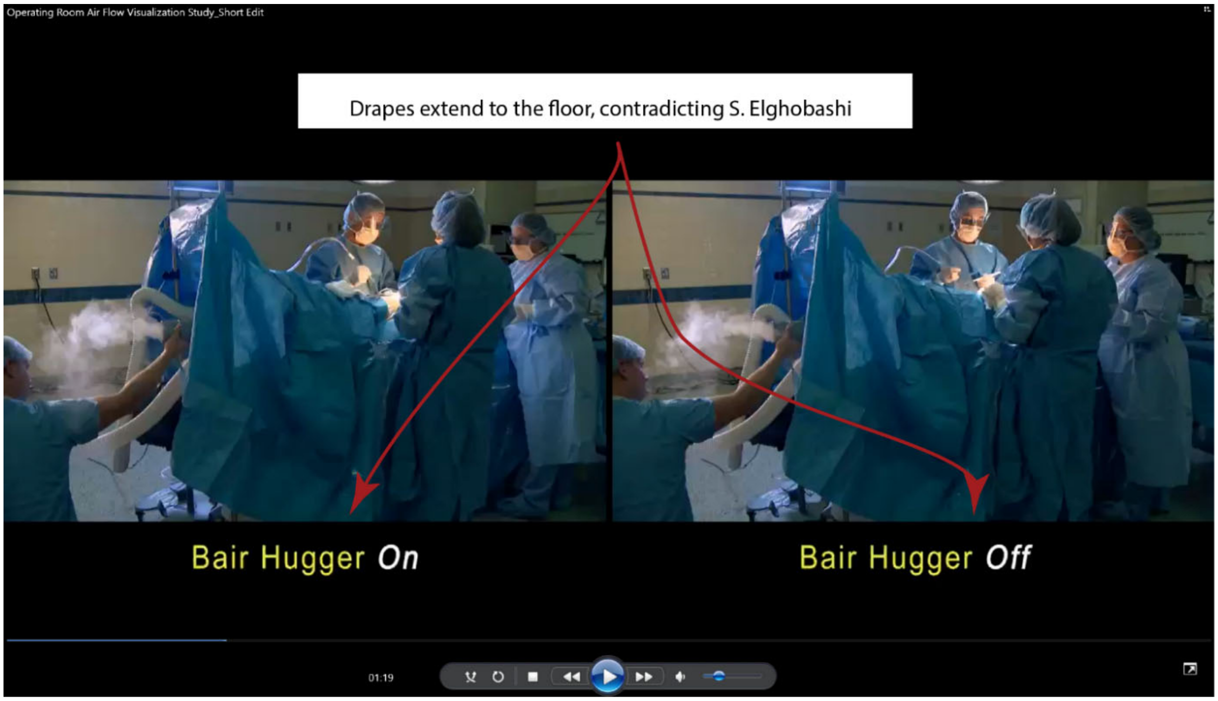
Additionally, here I identify new errors in the analysis of Dr. Elghobashi, which I will now discuss.

Newly Identified Error 1:
First, I show a photograph from a March 23, 2022 presentation given by Dr. Elghobashi related to the work he contracted to complete the simulations. In the photograph, the drapes extend nearly to the floor around the OR table.



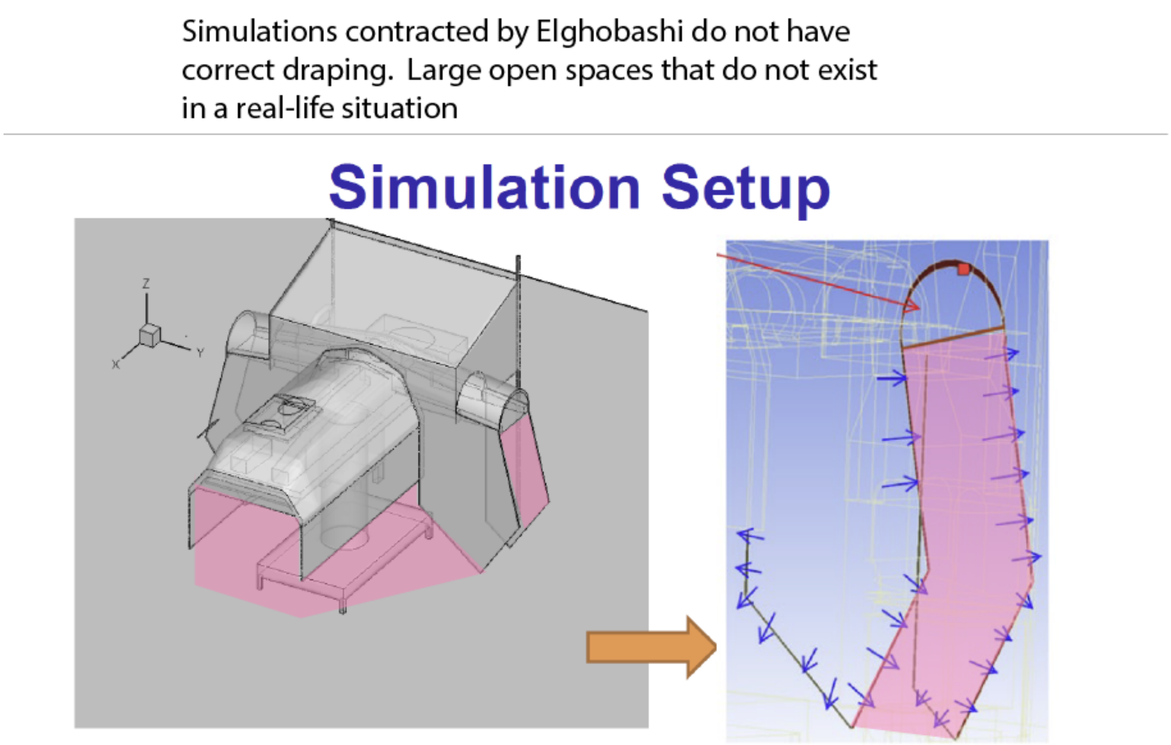
From Dr. Elghobashi presentation – shows patient draping extending to floor

The draping shown in the following image comports with draping that I observed in a mock OR surgery that utilized the BH FAW. The next figure shows draping extending to the floor during my mock surgery experiment. This is something omitted from the simulation that Dr. Elghobashi had contracted to a third party.

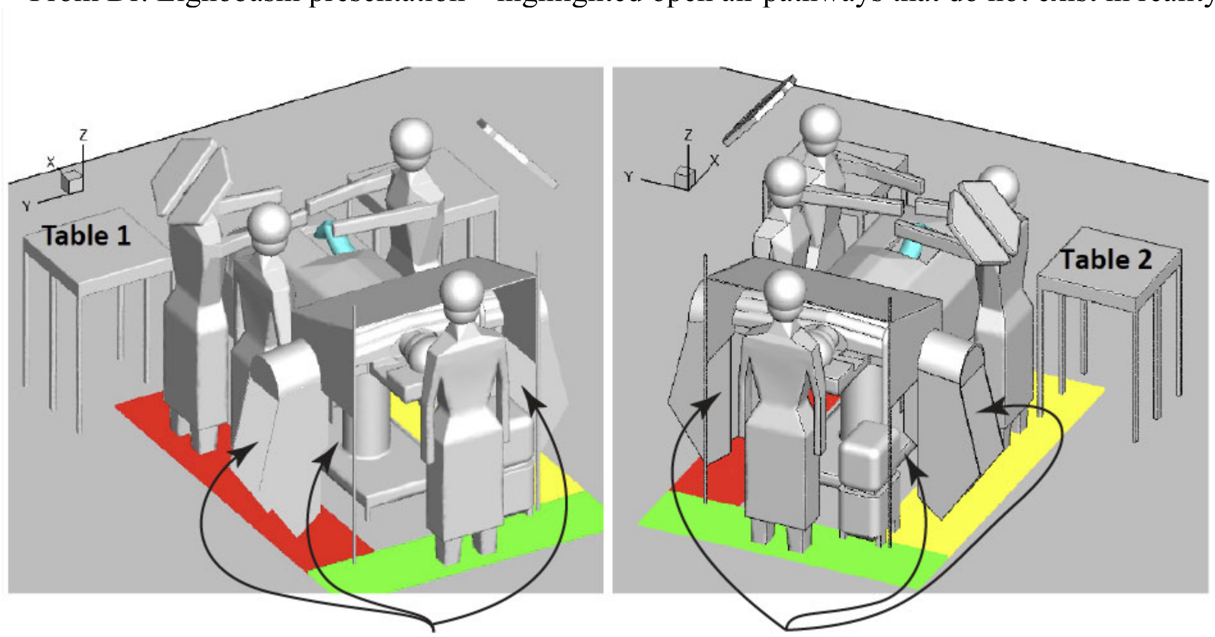


Drapes extend from OR to the floor

Next, I show three sets of images from the same Dr. Elghobashi presentation. Stunningly, Dr. Elghobashi has removed these drapes and he has allowed large open pathways underneath the table.



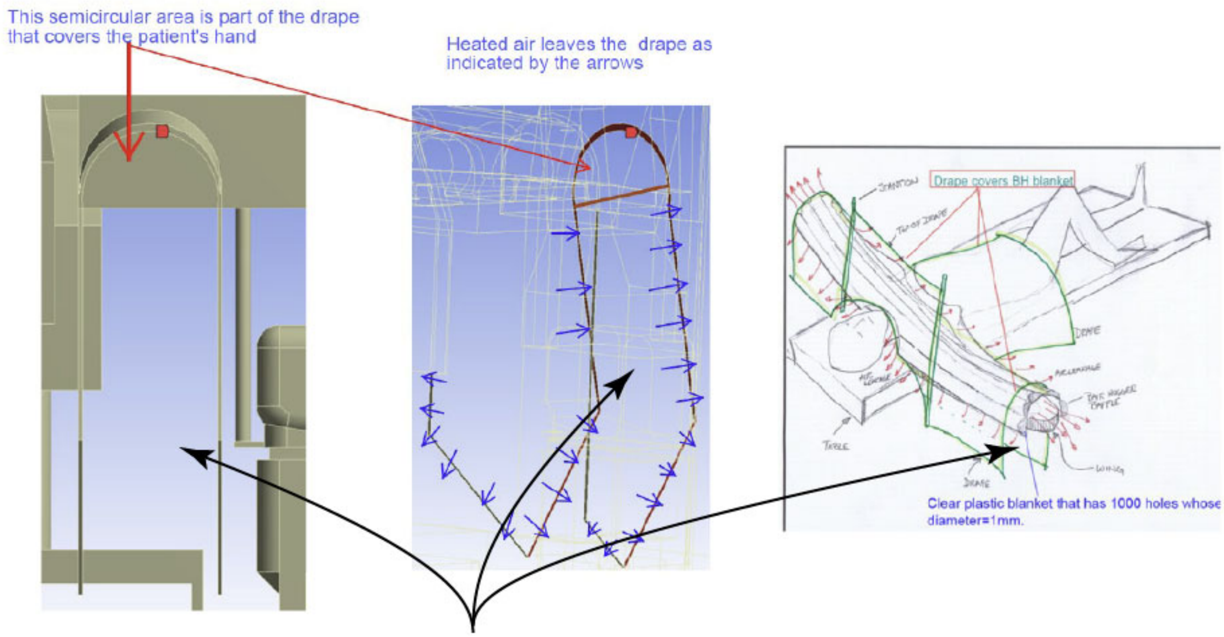
From Dr. Elghobashi presentation – highlighted open air pathways that do not exist in reality



From Dr. Elghobashi presentation – multiple open air passages that do not exist in reality.

Blanket and Drape Details

- Drape geometrical details were obtained from measurements in an OR in Santa Monica, California, on Sept. 24, 2016 (see photos).



In Elghobashi contracted simulation, there are no blockages underneath drapes so it is possible to look entirely across the OR table with an unimpedded view. This contradicts his own presentation and it is incorrect.

From Dr. Elghobashi presentation – open pathways that do not actually exist

Newly Identified Error 2:
During a March 24th, 2022 deposition, Dr. Elghobashi testified that the shape of the room does not matter (Dr. Elghobashi deposition, page 32, lines 10-15). Rather, he opined that only the volume matters. He is incorrect. The shape of a room matters both in its height and in the floor plan. Air flow in a wide but short room differs from the airflow that would occur in a narrow tall room, particularly for an operating room with buoyant air currents that rise and fall because of their temperature. In addition, air flow patterns in a square-shaped room would differ from patterns in an L-shaped space, as an example, even though both rooms may have the same volume. To use another example, according to Dr. Elghobashi, the airflow patterns in a room and a hallway would be similar to each other, provided they have the same volume. Such opinions are demonstrably false. I note that Dr. Elghobashi has performed no analysis or calculation to support his claim. On the other hand, I have worked in the HVAC industry (Heating, Ventilation, and Air Conditioning) and I can attest that the shape of a space affects the flow of air within the space.

Newly Identified Error 3:
According to Dr. Elghobashi's contracted simulations, everyone operated on with a BH FAW would become infected. His opinion is that hundreds of bacteria will reach the surgical site in a very short time (less than one minute). If true, infections would be very common or ubiquitous.

In his report, as well as his March 23, 2022 presentation, Dr. Elghobashi's contracted simulations followed airflow for ~ 30 seconds (SE Seminar-OR-Gabriel—March-23-2022, page 28/43). Those calculations purportedly show that within approximately 25 seconds, squames reach the patient's knee. In fact, after approximately 25 seconds, he opines that ~ 250 squames have reached the knee location. If this were correct, it would mean that every patient who is warmed with a BH FAW system would have pathogens reach the surgical site in less than one minute. Hip and knee replacement surgeries are long duration. While I am not a medical doctor and I am not offering any opinions on the standard of care or the exact duration of a surgery, I know that surgeries are much longer than 25 seconds. If these calculations were correct, every such operation would lead to thousands of squames reaching the surgical site and would lead to extremely high infection rates. In real life, infection rates when using a BH FAW device are very low – thus contradicting Dr. Elghobashi's opinions. The following image, from Dr. Elghobashi's 2022 presentation, shows that shortly after 20 seconds, the number of squames reaching the surgical site begin to rise rapidly and continue to rise thereafter.

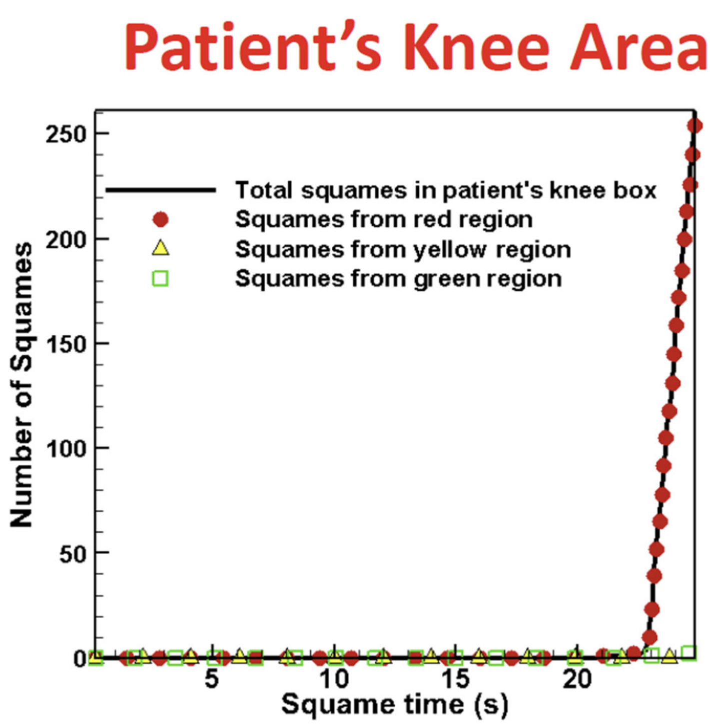


Image from Dr. Elghobashi March 23, 2022 presentation. According to his contracted calculations, approximately 250 squames reach the patient's knee in approximately 25 seconds. The number of squames continues to increase over time. If this were correct, infections would be ubiquitous. This result is unrealistic and reflects the faults in Dr. Elghobashi's analysis.

Newly Identified Error 4:
In the calculations that Dr. Elghobashi contracted out, he completely ignored bacteria shed by both the patient and the medical staff. This is particularly troublesome because bacteria shed by the medical staff would be above the surgical site and would be carried downwards toward the operating table by the airflow. Thus, he omits a major threat of infection from his calculations. As I have shown, previous researchers have included shed bacteria in their analysis; it is unclear why bacteria were neglected in the calculations outsourced by Dr. Elghobashi.

6. CONCLUDING REMARKS

In summary, the published literature demonstrates that there are many disturbances that can affect operating room air patterns. A number of those disturbances would have been present during Ms. O'Haver's surgery, including the position and movement of surgical lights; the number, position, and movement of surgical staff; the opening and closing of doors; the shape of the room; the size of the room; the actual ventilation flowrate, and the presence of other equipment that heats or disturbs the air; bacteria shed by the staff or the patient; breathing of the staff and patient; the temperature of the air entering the room, and the temperature distribution both within the room and between the room and adjoining spaces; and the positions and type of inlet and exhaust vents. Dr. Elghobashi ignored these factors, and his models therefore cannot predict what happened during Ms. O'Haver's surgery. Any reliance on Dr. Elghobashi's outsourced work to infer specific causation in Ms. O'Haver's case would be invalid and misguided.

Computational fluid dynamics is limited to answering very specific questions. Computational fluid dynamics as performed in this case ignores the major disturbances of airflow, such as the position and movement of the surgical lights or other obstructions, the position and movement of the surgical team, opening and closing of doors, breathing of the staff and patient, bacterial shedding from the staff and patient, the flow and temperature patterns of air exiting the vents, and the position and strength of heat or flow generating equipment. Insofar as the computational model differs from the real world in the positioning of ceiling vents that provide air to the room, the positioning of return vents that allow air to leave the room, the type of air exhaust vents (passive vs. powered), the shape of the room, the size of the room, the position and movement of equipment which affects air flow in the room, and the position and movement of staff, it cannot be predictive. Computational fluid dynamics cannot predict the trajectory of a bacterium or skin squame when the most important factors are ignored. Thus, the Plaintiff's CFD models cannot be used to show where particles would have traveled or landed during Ms. O'Haver's surgery, and do not support the Plaintiff's claim that the use of the Bair Hugger during her surgery caused or contributed to her development of a surgical infection.

I reserve the right to supplement this declaration as new facts and information are made available. I affirm that all the statements made herein of my own knowledge are true and that all statements are made on information and belief that they are true. Furthermore, these statements are made with the knowledge that willful false statements are punishable by fine, imprisonment, or both.

I declare under penalty of perjury that the foregoing is true and correct.

John Abraham

J.P. Abraham, Ph.D.

References

[1] Whyte W, Shaw BB, The effect of obstructions and thermal in laminar-flow systems. *Journal of Hygiene* 72:1974;415-423.
[2] Zoon WAC, van der Heijden MGM, Loomans MGLC, Hensen JLM, On the applicability of the laminar flow index when selecting surgical lighting. *Building and Environment* 45:2010;1976-1983.
[3] Sadrizadeh S, Holmberg S, Surgical clothing systems in laminar airflow operating room: A numerical Assessment. *Journal of Infection and Public Health* 7:2014;508-516.
[4] Sadrizadeh S, Holmberg S, Tammelin A, A numerical investigation of vertical and horizontal laminar airflow ventilation in an operating room. *Building and Environment* 82:2014;517-525.
[5] Wang C, Sadrizadeh S, Holmberg S, Influence of the shape of surgical lamps on the airflow and particle distribution in operating rooms. *Proceedings of the 11th International Conference on Air Distribution in Rooms*, May 24-27, 2009, Busan Korea.
[6] Refaie R, et al., The effect of operating lights on laminar flow. *The Bone and Joint Journal* 99:2017;B1061-1066.
[7] Cao G, et al., Do surgeons and surgical facilities disturb the clean air distribution close to a surgical patient in an orthopedic operating room with laminar air flow? *American Journal of Infection Control* (in press).
[8] McNeill J, Hertzberg J, Zhai Z, Experimental investigation of operating room air distribution in a full-scale laboratory chamber using particle image velocimetry and flow visualization, Journal of Flow Control, Measurement, and Visualization, 1:2013;24-32.
[9]Hermann-Rietschel-Institut (HRI), and provided online by the German Federal Ministry for Economic Affairs and Energy (https://blogs.tu-berlin.de/hri_op-luft/2019/01/04/closer-look-on-lamp-shapes/).
[10] Chow TT, Wang J, Dynamic simulation on impact of surgeon bending movement on bacteria-carrying particles distribution in operating theatre. *Building and Environment* 57:2012;68-80.
[11] Sadrizadeh S, Afshari A, Karimipanah T, Hakansson U, Nielsen PV, Numerical simulation of the impact of surgeon posture on airborne particle distribution in a turbulent mixing operating theatre, *Building and Environment* 110:2016;140-147.
[12] Brohus H, Balling KD, Jeppsen D, Influence of movements on contamination in an operating room *Proceedings of Indoor Air 2005* 3106-3111.
[13] Wong KY, et al, Effects of staff movement and air change rate on the airflow fields in an hospital's operating room. *IJCTA* 10:2017;265-275.
[14] Sadrizadeh S, Tammelin A, Ekolind P, Holmber S, Influence of staff number and internal constellation on surgical site infection in an operating room. *Particuology* 13:2014;42-51.
[15] Pokrywka P, Byers K, Traffic in the operating room: A review of factors influencing air flow and surgical wound contamination. *Infectious Disorders – Drug Targets* 13:2013;156-161.
[16] Tumia N, Ashcroft GP, Convection warmers – A possible source of contamination in laminar airflow operating theatres? *Journal of Hospital Infection* 52:2002;171-174.

[17] Smith EB, et al., The effect of laminar air flow and door openings on operating room contamination. *The Journal of Arthroplasty* 28:2013;1482-1485
[18] Saarinen PE, Kalliomaki P, Tang JW, Koskela H, Large eddy simulation of air escape through a hospital isolation room single hinged doorway – validation by using tracer gases and simulated smoke videos. *PLOS One* 10:2015;1-19.
[19] Kalliomaki P, Saarinen P, Wang JW, Koskela H, Airflow patterns through single hinged and sliding doors in hospital isolation rooms, *International Journal of Ventilation*, 14:2015;111-126.
[20] Villafruela JM, San Jose, JF, Castro F, Zarzuelo A, Airflow patterns through a sliding door during opening and foot traffic in operating rooms. *Building and Environment* 109:2016;190-198.
[21] Mears SC, Blanding R, Belkoff SM, Door opening affects operating room pressure during joint arthroplasty, *Orthopedics* 38:2015;e991-e994.
[22] Chang L, Tu S, Ye W, Zhang X, Dynamic simulation of contaminant in leakage produced by human walking into control room, *International Journal of Heat and Mass Transfer* 113;2017:1179-1188.
[23] Scaltriti S, et al., Risk factors for particulate and microbial contamination in air in operating theatres. *Journal of Hospital Infection* 66:2007;320-326.
[24] Wang J, Chow TT, Numerical investigation of influence of human walking on dispersion and deposition of expiratory droplets in airborne infection isolation rooms. *Building and Environment* 46:2011;1993-2002.
[25] Inthavong K, et al., A smoke visualization technique for wake flow from a moving human manikin, *Journal of Visualization*, 20;2017:125-137.
[26] Sadrizadeh S, et al., Airborne particle dispersion to an operating room environment during sliding and hinged door opening. *Journal of Infection and Public Health* (in press).
[27] Teter J, et al., Assessment of operating room airflow using particle counts and direct observation of door openings. *American Journal of Infection Control* 45:2017;477-482.
[28] Perez P, et al., Door openings in the operating room are associated with increased environmental contamination. *American Journal of Infection Control*, 46: 2018;954-956.
[29] Lydon GP, Ingham DB, Mourshed MM, Ultra clean ventilation system performance relating to airborne infections in operating theatres using CFD modelling. *Building Simulation* 7:2014;277-287.
[30] Zhou B, Ding L, Li F, Xue K, Nielsen PV, Xu Y, Influence of opening and closing process of sliding door on interface airflow characteristic in operating room, *Building and Environment* 144:2018;459-473.
[31] Elghobashi S, Expert Declaration in General Causation and Garreis v. 3M (Plaintiff)
[32] Shirozu K, et al., Effects of forced air warming on airflow around the operating table. *Anesthesiology* 128:2018;79-84.
[33] Ufat H, Kaynakli O, Yamankaradeniz N, Yamankaradeniz R, Three-dimensional air distribution analysis of different outflow typed operating rooms at different inlet velocities and room temperatures. *Advances in Mechanical Engineering* 9:2017;1-12.
[34] Abraham JP, Expert Declaration in General Causation and *Gareis v. 3M*

MATERIALS CONSIDERED

All materials listed or discussed in this report as well as in my prior reports

Abraham General Causation, *Gareis, Axline,* and *Trombley* Reports

Elghobashi General Causation, *Gareis, Axline,* and *Trombley* Reports

Abraham General Causation and *Gareis* deposition and trial testimony

Elghobashi General Causation and *Gareis* deposition and trial testimony

Schematic of O'Haver OR

Supplemental videos from Saarinen PE, Kalliomaki P, Tang JW, Koskela H, Large eddy simulation of air escape through a hospital isolation room single hinged doorway – validation by using tracer gases and simulated smoke videos. *PLOS One* 10:2015;1-19.

Supplemental videos from Villafruela JM, San Jose, JF, Castro F, Zarzuelo A, Airflow patterns through a sliding door during opening and foot traffic in operating rooms. *Building and Environment* 109:2016;190-198.

Supplemental videos from Inthavong K, et al., A smoke visualization technique for wake flow from a moving human manikin, *Journal of Visualization*, 20;2017:125-137.

Airflow videos provided by Technische Universitat Berlin Hermann-Rietschel-Institut

He et al., Effect of Heat-Air Blanket on Dispersion of Squames in an Operating Room, International Journal for Numerical Methods in Biomedical Engineering, Volume 34, May 2018.

Elghobashi, S., Effect of Forced-Air-Warming on Pathogens Dispersion in an Operating Room, March 23, 2022 ppt.

Exhibit A (J.P. Abraham CV)
SUMMARY

Thermal science expert with experience in all aspects of heat transfer and fluid mechanics. Produced approximately 400 publications, books, book chapters, conference presentations, and patents in areas including biological heat transfer and fluid flow, biomedical device design, energy, burn injuries, climate change, fundamental heat transfer and fluid mechanics, and manufacturing processes. Author of approximately 350 popular press articles and has been in approximately 120 radio and television appearances.

APPOINTMENTS

University of St. Thomas, St Paul, MN

Professor **2013-Present**

Associate Professor **2008-2013**

Assistant Professor **2002-2008**

EDUCATION

University of Minnesota - Twin Cities, Minneapolis, MN

Ph.D., Mechanical Engineering (Thermal Sciences) **2002**

M.S., Mechanical Engineering, GPA 3.96**/**4.00 **1999**

B.S., Mechanical Engineering, GPA 4.00/4.00, **Minor**: Mathematics **1997**

PREVIOUS TEACHING EXPERIENCE

Adjunct Faculty, *University of St. Thomas, St Paul, MN* **2000-2002**

Graduate Teaching Fellow, *University of Minnesota, Minneapolis, MN* **2001-2002**

Teaching Assistant*,* *University of Minnesota, Minneapolis, MN* **1997-2001**

Tutor, *University of Minnesota, Minneapolis, MN* **1993-1997**

HONORS/AWARDS

- Journal of Atmospheric and Oceanic Technology, Editor award (2020).
- National Center for Science Education, Friend of the Planet Award (2016)
- University of St. Thomas, Professor of the Year (2016)
- USA Green Deal of the Year business excellence award (2013)

- Composites Sustainability Award, American Composites Manufacturers Association Award for Composite Excellence, (2013)
- Nominated, George Mason University, Center for Climate Change Communication, Climate Change Communicator of the Year (2011)
- University of St. Thomas, John Ireland Award (2009)
- University of St. Thomas, Distinguished Educator Award (2008)
- University of St. Thomas, Engineering Professor of the Year (2005)
- Graduate Teaching Fellowship (2001/2002)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (1999/2000)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (2000/2001)
- Institute of Technology Teaching Assistant of the Year, awarded by Institute of Technology Student Board, University of Minnesota (2001/2002)
- Mechanical Engineering Teaching Assistant of the Year, Mechanical Engineering Department, University of Minnesota (1998/1999)
- Minnesota Professional Engineers Foundation Orion Buan Memorial Scholarship (1996)
- Walter and Margaret Pierce Endowment Fund Scholarship (1996)
- National Space Grant Consortium Scholarship (1996)
- Frank Louk Scholarship (1996)
- Citizens' Scholarship (1992-1995)
- Alfred O. Neir Scholarship (1994)
- Dean's List (1993-1997)

OTHER POSITIONS

Climate Blogger – Guardian Newspaper **2013-2022**

PUBLICATIONS

(17 edited works, 3 books, 30 book chapters, 249 journal publications, 146 presentations,15 granted patents, 5 patent applications, 2 granted trademarks)

TOP PUBLICATIONS BY ALTMETRIC

L. Cheng, J.P. Abraham, K.E. Trenberth, J. Fasullo, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, Z. Tan, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonov, J. Reagan, Another Record Ocean Warming Continues Through 2021 Despite La Nina Conditions, *Advances in Atmospheric Sciences,* Vol. 39, 373-385, 2022). **Altmetric score = 4686, top 1% in all journals, January 2022. This altmetric score places the paper in the top 0.02% (top 57 out of 287000 papers) in all journals, and within the top 1% of papers in the publishing journal.**

L. Cheng, J.P. Abrahm, K.E. Trenberth, J.T. Fasullo, T.L. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, M.E. Mann, F. Reserghetti, S. Simoncelli, V. Gouretski, G. Chen, and J. Zhu, Upper Ocean Temperatures Hit Record High in 2020, *Advances in Atmsopheric Sciences,* Vol. 38, pp. 523-530, 2021. **Altmetric score = 1439, top 1% in all journals, August 2021.**

G. Li, L. Cheng, J. Zhu, K.E. Trenberth, M.E. Mann and J.P. Abraham, Increasing Ocean Stratification Over the Past Half Century, *Nature Climate Change,* Vol. 10, pp. 1116-1123, 2020. **Altmetric score = 726, top 1%, July 2021.**

J.P. Abraham, B. D. Plourde, and L. Cheng, Using Heat to Kill SARS-CoV-2, *Reviews in Medical Virology*, Vol. 30, e2115, 2020. **Altmetric score = 392, top 1%, July, 2021.**

L. Cheng, J.P. Abraham, J. Zhu, K.E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M.E. Mann, Record-Setting Ocean Warmth Continued in 2019, *Advances in Atmospheric Sciences*, Vol. 37, 1-6, 2020. **This paper was in the top 100 of all published scientific papers in the year 2020, ranked by Altmetric. Also, second of all 2020 papers in the subject area of climate. Altmetric score = 3957, top 1%, January 2021.**

L. Cheng, J. Zhu, J.P. Abraham, K. E. Trenberth, J. T. Fasullo, B. Zhang, F. Yu, L. Wan, Z. Chen, X. Song, 2018 Continues record global warming, *Advances in Atmospheric Sciences*, 36, pp. 249-252, 2019. **Altmetric score = 646, top 1%, January 2021.**

L. Cheng, J.P. Abraham, Z. Hausfather, and K.E. Trenberth, How fast are the oceans warming?, *Science*, Vol. 363, pp. 128-129, 2019. **Altmetric score = 2853, top 1%, January 2021.**

L.J. Cheng, K.E. Trenberth, T. Boyer, J. T. Fasullo, L. Zhu, J.P. Abraham, Improved Estimates of Ocean Heat Content from 1960-2015, *Science Advances*, Vol. 4, paper no. e1601545, 2017. **Altmetric Score = 753, top 1%, January 2021.**

Editing Activities (17 editorial works)

1. Editor, Advances in Heat Transfer, Vol. 54, Elsevier, (forthcoming, 2022).
2. Editor, Advances in Heat Transfer, Vol. 53, Elsevier, 2021.
3. Editor, Advances in Heat Transfer, Vol. 52, Elsevier, 2020.
4. Editor, Advances in Heat Transfer, Vol. 51, Elsevier, 2019.
5. Editor, Advances in Heat Transfer, Vol. 50, Elsevier, 2018.
6. Editor, Advances in Heat Transfer, Vol. 49, Elsevier, 2017.

7. Editor, Advances in Heat Transfer, Vol. 48, Elsevier, 2016.
8. Editor, Advances in Heat Transfer, Vol. 47, Elsevier, 2015.
9. Editor, Advances in Heat Transfer, Vol. 46, Elsevier, 2014.
10. Editor, Advances in Numerical Heat Transfer Vol. 5: Numerical Models of Heat Exchangers, Taylor and Francis, New York, 2017.
11. Editor, Small-Scale Wind Power – Design, Analysis, and Economic Impacts, Momentum Press, 2014.
12. Editor, Advances in Heat Transfer, Vol. 45, Elsevier, 2013.
13. Editor, Advances in Heat Transfer, Vol. 44, Elsevier, 2012.
14. Editor, Advances in Numerical Heat Transfer Vol. 4: Nanoscale Heat Transfer and Fluid Flow, Taylor and Francis, New York, 2012.
15. Guest Editor, Advances in Numerical Heat Transfer Vol. 3: Numerical Implementation of Biological Models and Equations, Taylor and Francis, New York, 2009.
16. Guest Editor, Special Edition of the International Journal of Heat and Mass Transfer: Bioheat and Biofluid Flow, Elsevier, Vol. 51, 23-24, November, 2008.
17. Assistant Editor, Handbook of Numerical Heat Transfer, 2nd Ed. Editors: Sparrow, Minkowycz, and Murthy, John-Wiley & Sons, Inc., New York, 2006.

Books

1. J.P. Abraham and B.D. Plourde, Small-Scale Wind Power – Design, Analysis, and Environmental Impacts, *Momentum Press*, 2014.

2. J.P. Abraham, P.S. Ellis, M.C. MacCracken, and G.M. Woodwell, Climate controversy 2013. New York, NY: *AuthorHouse*, 2013.

3. J.P. Abraham, E.M. Sparrow, W.J. Minkowycz, R.Ramazani-Rend, and J.C.K. Tong, All Fluid-Flow-Regimes Simulation Model for Internal Flows, *Nova Science Publishers*, Inc., Hauppauge, NY, 2011.

Book Chapters (author of 30 book chapters)

1. R. Daneshfaraz, E. Aminvash, and J.P. Abraham, Hydraulic Characteristics of Fish-Passes on Inclined Drops, *Research Developments in Science and Technology* (in press).

2. F. Salamsi, J.P. Abraham, and A. Salamsi, Design Considerations for Pumping Stations Using Variable Speed Pumps, *Novel Perspectives of Engineering Research,* (in press).

3. F. Salamsi, J.P. Abraham, Drainage Gallery in Concrete Gravity Dams and its Effect on Reduction of Uplift Forces, *Novel Perspectives of Engineering Research,* (in press).

4. F. Salamsi, and J.P. Abraham, Numerical Simulation Using the Finite Element Method to Investigate the Effect of Horizontal Drains and Cutoff Walls on Seepage and Uplift Pressure in Heterogeneous Earth Dams, *Novel Perspectives of Engineering Research*, Vol. 9, pp. 58-85, 2022.

5. F. Salamsi, J.P. Abraham, B. Nourani, Determining the Analysis of the Stability of Embankments Against Sliding and Prediction of Sliding and Critical Factor of Safety, *Novel Perspectives of Engineering Research*, pp. 98-125, 2022.

6. F. Salamsi and J.P. Abraham, Effect of Horizontal Drain Length and Cutoff Wall on Seepage and Uplift Pressure in Heterogeneous Earth Dam with Numerical Simulation, *Novel Perspectives of Engineering Research* (submitted).

7. F. Salamsi and J.P. Abraham, Numerical Investigation of Reduction of Uplift Forces by Drain Pipes Under the Bed of a Canal, *Novel Perspectives in Engineering Research*, 2022.

8. F. Salamsi and J.P. Abraham, A Case Study on the Weep Hole and Cutoff Wall Effect for Decreasing Uplift Pressure on Hydraulic Structures, *Innovations in Science and Technology*, Vol. 6, pp. 12-38, 2022.

9. F. Salamsi and J.P. Abraham, Comparison of Uplift Pressure and Hydraulic Gradient in Three Types of Dams: Concrete Gravity dams, Homogeneous, and Hetergogneous Earth-Filled Dams*, Innovations in Science and Technology*, Vol. 3, pp. 71-86, 2022.

10. F. Salamsi and J.P. Abraham, Geological Considerations in Dam Engineering, *Novel Perspectives of Engineering Research*, Vol. 6, 2022.

11. B.D. Plourde, J. Kilonzo, J. Kiplagat, J.P Abraham, and L. Cheng, From Sunlight to Drinking Water – The Design and Validation of a Solar-Pasteurization System, Published in *Handbook of Research on Heat Transfer*, edited by S. Bhattacharyya and V. Goel, Chapter 16, 2022.

12. A. Salamsi, J.P. Abraham, and F. Salamsi, Prospects for Application of Nanotechnology in Marine Industries, *Innovations in Science and Technology*, Vol. 4, pp. 84-106, 2022.

13. F. Salamsi and J.P. Abraham, Validity of Schaffernak and Casangrande analytical solutions for Seepage Through a Homogeneous Earth Dam and Comparison with Numerical Solutions Based on the Finited Element Method, in *Novel Perspectives of Engineering Research*, Vol. 4, pp. 79-93, 2021.

14. F. Salamsi and J.P. Abraham, Effect of Embankment Soil Layers on Stress-Strain Characteristics, *Recent Progress in Plant and Soil Research*, Vol. 4, pp. 68-84, 2021

15. F. Salamsi and J.P. Abraham, Study on the Effect of Inclination of Cutoff Wall Beneath Gravity Dams on Uplift Force, in *Novel Perspectives of Engineering Research*, Vol. 1, pp. 38-57, 2021.

16. J.P. Abraham, S. Bhattacharya, L. Cheng, and J.M. Gorman, A Brief History of and Introduction to Computational Fluid Dynamics, in *Computational Fluid Dynamics*, edited by: Suvanjan Bhattacharya, published by IntechOpen, 2021.

17. F. Salamsi and J.P. Abraham, The Method of Characteristics Applied to the Sensitivity Analysis for Water Hammer Problems, *New Approaches in Engineering Research*, B.P. International, Vol. 9, pp. 50-63, 2021.

18. J. Gorman, S. Bhattacharya, J.P. Abraham,, L. Cheng, Turbulence Models Commonly used in CFD, in: *Computational Fluid Dynamics*, edited by: Suvanjan Bhattacharya, published by IntechOpen, 2021.

19. J.M. Gorman, M. Regnier, and J.P. Abraham, Heat Exchange Between the Human Body and the Environment – A Comprehensive, Multi-Scale Numerical Simulation, in: *Advances in Heat Transfer*, Vol. 52, 2020.

20. L.E. Olsen, J.P. Abraham, L.J. Cheng, J.M. Gorman, E.M. Sparrow, Summary of Forced-Convection Fluid Flow and Heat Transfer for Square Cylinders of Different Aspect Ratios Ranging from the Cube to a Two-Dimensional Cylinder, in: *Advances in Heat Transfer*, Vol. 51, pp. 351-457, 2019.

21. E.M. Sparrow, J.M. Gorman, A. Ghoash, J.P. Abraham, Enhancement of Jet Impingement Heat Transfer by Means of Jet Axis Switching, in: *Advances in Heat Transfer,* Vol. 50, 2018.

22. E.M. Sparrow, J.M. Gorman, J.P. Abraham, W.J. Minkowycz, Validation of Turbulence Models for Numerical Simulation of Fluid Flow and Convective Heat Transfer, in: *Advances in Heat Transfer*, Vol. 49, 397-421, 2017.

23. J.M. Gorman, E.M. Sparrow, J.P. Abraham, W.J. Minkowycz, Heat Exchangers and Their Fan/Blower Partners Modeled as a Single Interacting System by Numerical Simulation, in: *Advances in Numerical Heat Transfer Vol. 5,* Taylor and Francis, New York, 2017.

24. J.P. Abraham, B.D. Plourde, L.J. Vallez, B.B. Nelson-Cheeseman, J.R. Stark, J.M. Gorman, E.M. Sparrow, Skin Burn, in: *Theory and Application of Heat Transfer in Humans*, edited by Devashish Shrivastava, Wiley, June 2018.

25. M.W. Dewhirst, J.P. Abraham, B.L. Viglianti, Evolution of Thermal Dosimetry for Application of Hyperthermia Treatment to Cancer, in: *Advances in Heat Transfer*, Vol. 47, 397-421, 2015.

26. B.D. Plourde, E.D. Taylor, P.O. Okaka, and J.P. Abraham, Financial and Implementation Considerations for Small-Scale Wind Power, in: *Small-Scale Wind Power – Design, Analysis, and Economic Impacts*, Momentum Press, 2014.

27. B.D. Plourde, E.D. Taylor, W.J. Minkowycz, and J.P. Abraham, Introduction to Small-Scale Wind Power, in: *Small-Scale Wind Power – Design, Analysis, and Economic Impacts*, Momentum Press, 2014.

28. J.P. Abraham, E.M. Sparrow, W.J. Minkowycz, R. Ramazani-Rend, and J.C.K. Tong, Modeling Internal Flows by an Extended Menter Transition Model, in: *Turbulence: Theory, Types, and Simulation*, Nova Publishers, New York, 2011.

29. S. Ramadhyani, J.P. Abraham, and E.M. Sparrow, A Mathematical Model to Predict Tissue Temperatures and Necrosis During Microwave Thermal Ablation of the Prostate, in: *Advances in Numerical Heat Transfer Vol. 3: Numerical Implementation of Bioheat Models and Equations*, Taylor and Francis, New York, 2009.

30. J.P. Abraham and E.M. Sparrow, Heat-Transfer and Temperature Results for a Moving Sheet Situated in a Moving Fluid, in: *Heat-Transfer Calculations, 2nd ed.,* editor, Myer Kutz, McGraw-Hill, 2005.

Publications (author of 249 journal papers)

2022

1. J.P. Abraham, L. Cheng, M.E. Mann, K.E. Trenberth, K. von Schuckmann, The Ocean Response to Climate Change Guides Both Adaptation and Mitigation Efforts, *Atmospherical and Oceanic Science Letters*, (accepted).

2. L. Cheng, G. Foster, Z. Hausfather, K.E. Trenberth, J.P. Abraham, Improved Quantification of the Rate of Ocean Warming, *Journal of Climate*, (accepted).

3. F. Salamsi and J.P. Abraham, Effect of Slope on Energy Dissipation for Flow Over a Stepped Spillway, *Water Supply*, (accepted).

4. Y. Liu, L. Cheng, Y. Pan, Z. Tan, J.P. Abraham, B. Zhang, J. Zhu, and J. Song, How Well do CMIP6 and CMIP5 models simulate the climatological seasonal variations in ocean salinity, *Advances in Atmospheric Sciences*, (accepted).

5. J.M. Gorman, W. Tan, and J.P. Abraham, Numerical Simulation of Microwave Ablation in the Human Liver, Heat Transfer in Biomedical Applications, edited by A. Andreozzi, M. Iasiello, V. Timochenko, and K. Vafai, published in *Processes*, Vol. 10, paper no. 361, 2022.

6. F. Salamsi, S. Shadkani, J.P. Abraham, F. Malekzadeh, Experimental Investigation For Determination of Discharge Coefficients for Inclined Slide Gates and Comparison with Data-Driven Models, *Iranian Journal of Science and Technology, Transactions of Civil Engineering*, (in press), doi: 10.1007/s40996-022-00850-9.

7. F. Salamsi and J.P. Abraham Multivariate Nonlinear Regression for Predicting Free Falling-Jet Scouring: An Experimental Study, Iranian Journal of Science and Technology, *Transactions of Civil Engineering*, (in press) doi: 10.1007/s40996-022-00817-w.

8. F. Salamsi, J.P. Abraham, A. Salamsi, Evaluation of Variable Speed Pumps in Pressurized Water Distribution Systems, *Applied Water Science* (accepted).

9. J.P. Abraham, L. Cheng, P.L. Hudson, and A.N. Abraham, Assessing Burn Patterns and Severity Using IR Visualization – A Case Study Approach, *Journal of Forensic Science and Criminology,* Vol. 9, pp. 1-19, 2022.

10. J. P. Abraham, L. Cheng, L. Vallez, and T. Wei, Using Cadaver Temperatures to Estimate Time of Death, A Case-Specific Numerical Approach, *Journal of Forensic Sciences*, (in press).

11. L. Cheng, J.P. Abraham, K.E. Trenberth, J. Fasullo, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, Z. Tan, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonov, J. Reagan, Another Record Ocean Warming Continues Through 2021 Despite La Nina Conditions, *Advances in Atmospheric Sciences*, (in press).

12. R. Daneshfaraz, S. Sadeghfam, E. Arminvash, and J.P. Abraham, Experimental Investigation of Multiple Supercritical Flow States and the Effect of Hysteresis on the Relative Residual Energy in Sudden and Gradual Contractions, *Iranian Journal of Science and Technology, Transactions of Civil Engineering*, (in press).

13. R. Daneshfaraz, E. Aminvash, R. Mirzaei, and J.P. Abraham, Predicting the Energy Dissipation of a Rough Sudden Expansion Rectangular Stilling Basin Using the SVM Algorithm, *Journal of Applied Research in Wastewater*, (in press). Doi: 10.22126/arww.2021.5886.1195.

14. A. Armanous, A. Negm, A. Javadi, J.P. Abraham, and T. Gado, Impact of Inclined Double-Cutoff Walls Under Hydraulic Structures on Uplift Forces, Seepage Discharge, and Exit Hydraulic Gradient, *Ain Shams Engineering Journal*, Vol. 13, paper no. 101531, 2022. Doi: 10.1016/j.asej.2021.06.017.

15. R. Daneshfaraz, S. Sadeghfam, V. Hasanniya, J.P. Abraham, and R. Norouzi, Experimental Investigation on Hydraulic Efficency of Vertical Droip Equipped with Vertical Screens, *Teknit Dergi*, Vol. 33, no. 5, 2022. DOI: 10.18400/tekderg.755938.

16. A. Ghaderi, M. Dasineh, R. Danesfarak, and J.P. Abraham, Reply to the Discussion on Paper: 3-D Numerical Simulation of Water Flow over a Broad Created weir with Openings by Daneshfaraz et al 2019, *ISH Journal of Hydraulic Engineering*, Vol. 28,pp. 564-566, 2022.

17. F. Salamsi and J.P. Abraham, Discharge Coefficients for Ogee Spillways, Water Supply, Vol. 22, pp. 1255-1274, 2022.

18. R. Norouzi, P. Sihag, R. Daneshfaraz, J.P Abraham, and V. Hasanna, Predicting Relative Energy Dissipation for Vertical Drops Equipped with a Horizontal Screen Using Soft Computing Techniques, *Water Supply*, Vol. 22, pp. 1075-1093, 2022.

19. F. Malekzadeh, F. Salamsi, J.P. Abraham, and H. Arvanaghi, Numerical Investigation of the Effect of Geometric Parameters on Discharge Coefficients for Broad-Crested Weirs with Sloped Upstream and Downstream Faces, *Applied Water Science*, Vol. 12, paper no. 110, 2022.

2021

20. F. Salamsi and J.P. Abraham, Genetic Algorithms to Optimizing Stepped Spillways to Maximize Energy Dissipation, *Water Supply*, (accepted). Doi 10.2166/ws.2021.353.

21. M. Seifollahi, S, M. Lotfollahi-Yaghin, F. Kalateh, R. Daneshfaraz, S. Abbasi, and J.P. Abraham, Estimation of the Local Scour from a Cylindrical Bridge Pier Using a Compilation Wavelet Model and Artificial Neural Network, *Journal of Hydraulic Structures,* Vol. 7, pp. 1-22, 2021.

22. B. Ferry and J.P. Abraham, Mechanical Design of Long-Term Body-Adhered Medical Devices to Maximize On-Body Survival, *Journal of Biomedical Science and Engineering*, Vol. 19, pp. 325-337, 2021.

23. Y. Liu, L. Cheng, Y. Pan, J.P. Abraham, B. Zhang, J. Zhu, and J. Song, Climatological seasonal variation of the upper ocean salinity, *International Journal of Climatology*, doi: 10.1002/joc.7428.

24. F. Salamsi, J.P. Abraham, and A. Salmasi, Effect of Stepped Spillways on Increasing Dissolved Oxygen in Water, an Experimental Study, *Journal of Environmental Management*, Vol. 299, paper 113600, 2021.

25. C. Garcia-Soto, L. Cheng, L. Caeser, E.B. Jewett, A. Cheripka, I.G. Rigor, A. Cabellero, S. Chiba, J.C. Baez, T. Zielinski, and J.P. Abraham, An Overview of Ocean Climate Change Indicators: Sea Surface Temperature, Ocean Heat Content, Ocean pH, Dissolved Oxygen Concentration, Artic Ice Extent, Thickness, and Volume, *Frontiers in Marine Science, Global Ocean and Future Ocean,* doi: `0.3389/fmars.2021.642372, 2021.

26. J.P. Abraham, T. Wei, and Y. Wang, Layered Structure of Turbulent Natural Convection Over a Vertical Flat Plate, *International Journal of Heat and Mass Transfer*, Vol. 181, paper 121866, 2021.

27. F. Salamsi, F. Nahrain, J.P. Abraham, and A.T. Aghdam, Prediction of Discharge Coeefficients for Broad-Crested Weirs Using Expert Systems, *Journal of Hydraulic Engineering*, doi: 10.1080/09715010.2021.1983477.

28. F. Salamsi and J.P. Abraham, Closure to “Expert System for Determining Discharge Coefficients for Inclined Slide Gates Using Genetic Programming”, *Journal of Irrigation and Drainage Engineering,* Vol. 147, paper no. 07021018, 2021.

29. L. Olsen, S. Bhattacharyya, L. Cheng, W. Minkowycz, and J. Abraham, Heat Transfer Enhancement for Internal Flows with a Centrally Located Circular Obstruction and the Impact of Buoyancy, *Heat Transfer Engineering* doi: 10.1080/01457632.2021.2016129.

30. F. Salamsi and J.P. Abraham, Closure to “Discharge Coefficients for Rectangular Broad-Crested Gabion Weirs: An Experimental Study”, *Journal of Irrigation and Drainage Engineering*, Volume 147, 2021.

31. R. Daneshfaraz, E. Aminvash. S. Di Francesco, A. Najibi, and J.P. Abraham, Three-Dimensional Study of the Effect of Block Roughness Geometry on Inclined Drop, *Journal of Numerical Methods in Civil Engineering*, Vol. 6, pp. 1-9, 2021.

32. J.C.K. Tong, J.M.Y. Tse, J.P. Abraham, P.J. Jones, Correlation Between Simulations and Measuremants of an Eco-House Design for Mongolia, *Journal of Building Engineering*, Vol. 42, no. 10, paper no. 102774, 2021. DOI:10.1016/j.jobe.2021.102774.

33. R. Daneshfaraz, M. Abam, M. Heidarpour, S. Abbasi, M. Seifollahi, and J.P. Abraham, The Impact of Cables on Local Scouring of Bridge Piers Using Experimental Study and ANN, ANFIS Algorithms, *Water Supply* (in press). DOI:10.2166/ws2021.215

34. R. Daneshfaraz, E. Aminvash, A. Ghaderi, A. Kuriqi, and J.P. Abraham, Three-Dimensional Investigation of Hydraulic Properties of Vertical Drop in the Presence of Step and Grid Dissipators*, Symmetry, Computer Engineering Science and Symmetry Turbulence and Multiphase Flows*, Vol. 13, paper no. 895, 2021.

35. T. Wei, Y. Wang, and J.P. Abraham, Integral Properties of Turbulent Natural Convection over a Vertical Flat Plate, *International Communications in Heat and Mass Transfer*, Vol. 125, paper 105286, 2021.

36. R. Daneshfaraz, E. Aminvash, A. Ghaderi, M. Bagherzadeh, J.P. Abraham, SVM Performance in Predicting the Effect of Horizontal Screens on Vertical Hydraulic Performance of a Vertical Drop, *Applied Sciences*, Vol. 11, no. 9, paper no. 4238, 2021. DOI: 10.3390/app11094238.

37. F.Salamsi, M. Nouri, P. Sihag, and J.P. Abraham, Application of SVM, ANN, GRNN, RF, GP, and RT Models for Predicting Discharge Coefficients of Olique Sluice Gates Using Experimental Data, *Water Supply*, Vol. 21, pp. 232-248, 2021.

38. A. Aghdam, F. Salamsi, J.P. Abraham, and H. Arvanaghi, Effect of Drain Pipes on Uplift Force and Exit Hydraulic Gradient and the Design of Gravity Dams Using the Finite Element Method, *Geotechnical and Geological Engineering*, Vol. 39, pp. 3383-3399, 2021.

39. Z. Tan,F. Reseghetti, J.P. Abraham R. Cowley, K. Chen, J. Zhu, B. Zhang, and L. Cheng, Examining the Influence of Recording System on the Pure Temperature Error in XBT Data, *Journal of Atmospheric and Oceanic Technology,* Vol. 38, pp . 759-776, 2021.

40. R. Daneshfaraz, V. Hasannia, R. Norouzi, P. Sihag, S. Sadeghfam, and J.P. Abraham, Investigating the Effect of Horizontal Screen on Hydraulic Parameters of a Vertical Drop, Iranian Journal of Science and Technology, *Transactions of Civil Engineering*, Vol. 45, pp. 1909-1917, 2021.

41. L. Cheng, J.P. Abraham, K.E. Trenberth, J.T. Fasullo, T.L. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, M.E. Mann, F. Reserghetti, S. Simoncelli, V. Gouretski, G. Chen, and J. Zhu, Upper Ocean Temperatures Hit Record High in 2020, *Advances in Atmospheric Sciences,* Vol. 38, pp. 523-530, 2021. **Altmetric score = 1057, top 1%, January 2021.**

42. M. Nouri, P. Sihag, F. Salamsi, and J.P. Abraham, Prediction of Homogeneous Earthen Slope Safety Factors Using the Forest and Tree Based Modeling, *Geotechnical and Geological Engineering*, Vol. 39, paper no. 04020148, 2021.

43. F. Salamsi, B. Nourani, J.P. Abraham, and R. Nouzi, Numerical Investigation of Relief Well Performance for Decreasing Uplift Pressure Under Embankment Dams, *International Journal of Environmental Science and Technology*, Vol. 18, pp. 2819-2830, 2021. doi: 10.1007/s13762-020-03030-2.

44. R. Daneshfaraz, M. Bagherzadeh, R. Esmaeeli, R. Norouzi, and J.P. Abraham, Study of the Performance of Support Vector Machine for Predicting Vertical Drop Hydraulic Parameters in the Presence of Dual Horizontal Screens, *Water Supply,* Vol. 21, pp. 217-231, 2021.

45. F. Salamsi, J.P. Abraham, Prediction of Discharge Coefficients for Sluice Gates Equipped With Different Geometry Sills Under the Gate Using Multiple Non Linear Regression (MNLR), *Journal of Hydrology*, Vol. 597, paper 125728, 2021. doi:10.1016/j.jhydrol.2020.125728.

46. F. Salamsi, N. Sabahi, and J. P. Abraham, Discharge Coefficients for Rectangular Broad Crested Gabion Weirs: An Expertimental Study, *Journal of Irrigation and Drainage Engineering,* Vol. 147, paper 04021001, 2021.

47. M. Asl, R. Daneshfaraz, J.P. Abraham, S. Valizadeh, Effects of Hydraulic Characteristics, Sedimentary Parameters, and Mining of Bed Material on Scour Depth of Bridge Pier Groups, *Joural of Performance of Constructed Facilities*, Vol. 35, paper no. 04020148, 2021.

48. G. Li, L. Cheng, J. Zhu, K.E. Trenberth, M.E. Mann and J.P. Abraham, Increasing Ocean Stratification Over the Past Half Century, *Nature Climate Change,* Vol. 10, pp. 1116-1123, 2020. **Altmetric score = 700, top 1%, July 2021.**

49. N. Sartipi, F. Salamsi, J. Abraham, and A.D. Dalir, Investigation of the Effect of Depth and Distance Between Cutoff Walls on Uplift Force for Gravity Dams, *International Journal of Environmental Science and Technology*, Vol. 18. pp. 1361-1378, 2021.

50. R. Daneshfaraz, R. Norouzi, M. Macedi, A. Bazyar, and J.P. Abraham, Laboratory Study of Energy dissipation in Inclined Drops with a Screen, *Journal of Applied Water Engineering and Research*, Vol. 9, pp. 184-193, 2021.

51. A. Ghaderi, R. Daneshfaraz, J.P. Abraham, and M. Torabi, Effect of Different Channels on Discharge Coefficient of Labyrinth Weirs, *Teknik Dergi*, Vol. 32 paper no. 626, pp. 11081-11096, 2021.

2020

52. A. Ghaderi, R. Daneshfaraz, S. Abbasi, and J.P. Abraham, Numerical Analysis of the Hydraulic Characteristics of Modified Labyrinth Weirs, *International Journal of Energy and Water Resources*, Vol. 4, pp. 425-436, 2020.

53. F. Salamsi and J.P. Abraham, An Expert System for Determining Discharge Coefficients for Inclined Slide Gates Using Genetic Programing, *Journal of Irrigation and Drainage Engineering*, Vol. 146, paper number 060200013, 2020.

54. A. Ghaderi, M. Shokri. J.P. Abraham, Estimation of Actual Evapotranspiration Using Remote Sensing Method and SEBAL Algorithm- A Case Study: Ein Khosh Plain, Iran, *Hydrology*, Vol. 7, doi: 10.3390/hydrology7020036, 2020.

55. F. Salamsi, M. Nouri, and J.P. Abraham, Upstream Cutoff and Downstream Filters to Control Seepage in Dams, *Water Resources Management*, Vol. 34, pp. 4271-4288, 2020.

56. L. Cheng, K.E. Trenberth, N. Gruber, M.E. Mann, J.P. Abraham, J.T Fasullo, G. Li, X. Zhao, and J. Zhu, Improved Estimates of Changes in Upper Ocean Salinity and the Hydrological Cycle, *Journal of Climate*,Vol.33, pp. 10357-10381, 2020.

57. F. Salamsi, R. Norouzi, J.P. Abraham, B. Nourani, S. Samadi, Effect of Inclined Clay Core on Embankment Dam Seepage and Stability Through LEM and FEM, *Geotechnical and Geological Engineering*, Vol. 38, pp. 6571-6586, 2020.

58. A. Ghaderi, R. Daneshfaraz, S. Abbasi, and J.P. Abraham, Numerical Analysis of the Hydraulic Characteristics of Modified Labyrinth Weirs, *International Journal of Energy and Water Resources,* Vol. 4, pp. 425-436, 2020.

59. J.P. Abraham, B. D. Plourde, and L. Cheng, Using Heat to Kill SARS-CoV-2, *Reviews in Medical Virology*, Vol. 30, e2115, 2020. **Altmetric score = 376, top 1%, July, 2021.**

60. A. Ghaderi, R. Daneshfaraz, M. Torabi, J.P. Abraham, and H.M. Azamathulla, Experimental Investigation on Effectiving Scouring Parameters Downstream from Stepped Spillways, *Water Supply*, Vol. 20, pp. 1988-1998, 2020.

61. F. Salamsi, and J.P. Abraham, Predicting Seepage from Unlined Earthen Channels Using the Finite Element Method and Multi Variable Nonlinear Regression, *Agriculatural Water Management*, Volume 234, Paper no. 106148, 2020.

62. F. Salamsi, B. Naourani, and J.P. Abraham, Investigation of the Effect of Different Configurations of Double-Cutoff Walls Beneath Hydraulic Structures on Uplift Forces and Exit Hydraulic Gradients, *Journal of Hydrology*, vol. 586, dpo: 10.1016/j.hydrol.2020.123858, 2020.

63. A. Ghaderi, S. Abbasi, J.P. Abraham, H. M. Azamathulla, Efficiency of Trapezoidal Labyrinth Shaped Stepped Spillways, *Flow Measurement and Instrumentation*, paper no. 101711, 2020, doi: 10.1016/j.flowmeasinst.2020.101711.

64. L. Cheng, J.P. Abraham, J. Zhu, K.E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M.E. Mann, Record-Setting Ocean Warmth Continued in 2019, *Advances in Atmospheric Sciences*, Vol. 37, 1-6, 2020. **(This paper was in the top 100 of all published scientific papers in the year 2020, ranked by Altmetric. Also, second of all 2020 papers in the subject area of climate. Altmetric score = 3957, top 1%, January 2021).**

65. F. Salamsi, and J.P. Abraham, Discussion of "Hydrodynamics of Rectangular Broad-Crested Porous Weirs" by Akbar Safarzadeh and Seyed Hossein Mohajeri, *J. Irrig. Drain. Eng*. Vol. 146, paper no. 07020004, 2020.

66. R. Daneshfaraz, M.M. Asl, S. Razmi, R. Norouzi, and J.P. Abraham, Experimental Investigation of the Effect of Dual Horizontal Screens on the Hydraulic Performance of a Vertical Drop, *International Journal of Environmental Science and Technology*, Vol. 17, pp. 2927-2937, 2020.

67. J.M. Gorman, et al., Memoriam, Ephraim Sparrow, *International Journal of Heat and Mass Transfer*, Vol. 148, article no. 18755, 2020.

68. F. Salmasi, J.P. Abraham, Discharge Coefficients for Ogee Weirs Including the Effects of a Sloping Upstream Face, *Water Science and Engineering*, doi: 10.2166/ws.2020.064, 2020.

69. F. Salamsi, and Abraham J.P., Discussion of "Hydrodynamics of Retangular Broad-Crested Porous Weirs" by Akbar Safrazadeh and Seyed Moharjeri, *Journal of Irrigation and Drainage Engineering*, Vol. 146, doi: 10.1061/%28ASCE%29IR.1943-4774.0001450, 2020.

70. R. Daneshfaraz, E. Aminvash, R. Esmaeli, S. Sadeghfam, and J.P. Abraham Experimental and Numerical Investigation for Energy Dissipation of Supercritical Flow in Sudden Contractions*, Journal of Groundwater Science and Engineering*, Vol. 8, pp. 396-404, 2020.

71. R. Daneshfaraz, O. Minaeri, J.P. Abraham, and S. Dadashi, 3-D Numerical Simulation of Flow Over a Broad-Crested Weir with Opening, *Journal of Hydraulic Engineering*, Vol. 24, doi: 10.1080/09715010.1581098, 2020.

2019

72. A. Ghaderi, M. Dasineh, S. Abbasi, and J.P. Abraham, Investigation of Trapezoidal Sharp-Crested Weir Discharge Coefficients Under Subcritical Flow Regimes, *Applied Water Science*, Vol. 10, article no. 31, 2019.

73. G. Li, Y. Zhang, J. Xiao, J.P. Abraham, L. Cheng, and J. Zhu, Examining the Salinity change in the upper Pacific Ocean During the Argo Period, *Climate Dynamics* Vol. 53, pp. 6055-6074, 2019.

74. J.P. Abraham, K. Diller, A Review of Hot Beverages – Satisfying Consumer Preferences and Safety, *J. Food Science*, Vol. 84, pp. 2011-2014, 2019.

75. J.M. Gorman, et al., In Memoriam, Ephraim M. Sparrow (May 27, 1928 – August 1, 2019), *Numerical Heat Transfer Part A*, Vol. 76, pp. 181-184, 2019.

76. F. Jafari, F. Salamsi, and J.P. Abaham, Numerical Investigation of Granular Filer Under the Bed of a Canal, *Applied Water Science*, Vol. 9, Article no. 137, 2019

77. J. P. Abraham, Heat risks associated with synthetic fields, *International Journal of Hyperthermia*, Vol. 24, pp. 516-517, 2019.

78. T. Wei and J.P. Abraham, Heat Transfer Regimes in Fully Developed Circular tube flows, a map of flow regimes, *International Communications in Heat and Mass Transfer*, Vol. 104, 147-152, 2019.

79. B.D. Plourde, A. Gikling, T. Marsh, M.A. Riemenschneider, J.L. Fitzgerald, W.J. Minkowycz, J. Kiplagat, J.P. Abraham, Design and Evaluation of a Concentrated Solar-Powered Thermal-Pasteurization System, *Journal of Solar Energy Research*, Vol. 6, pp. 34-42, 2019.

80. E. Dodangeh, K. Shahedi, K. Solalani, J.T., Shiu, J.P. Abraham, Data-Based Bivariate Uncertainty Assessment of Extreme Rainfall-Runoff Using Copulas: Comparison Between Annual Maximum Series (AMS) and Peaks Over Threshold (POT), *Environmental Monitoring and Assessment*, Vol. 191:67, 2019.

81. F. Salamsi, M. Nouri, and J.P. Abraham, Laboratory Study of the Effect of Sills on Radial Gate Discharge Coefficient, *KSCE Journal of Civil Engineering*, Vol. 23, pp. 2117-2125, 2019.

82. Benoit et al., Measuring Global Ocean Heat Content to Estimate the Earth Energy Imbalance, *Frontiers in Marine Science*, *OceanObs'19: An Ocean of Opportunity*, Vol. 6, pp. 198-228, doi: 10.3389/fmars.2019.00432, 2019.

83. L. Cheng, J. Zhu, J.P. Abraham, K. E. Trenberth, J. T. Fasullo, B. Zhang, F. Yu, L. Wan, Z. Chen, X. Song, 2018 Continues Record Global Warming, *Advances in Atmospheric Sciences*, 36, pp. 249-252, 2019. **Altmetric score = 646, top 1%, January 2021.**

84. L.Cheng, G. Wang, J.P. Abraham, G. Huang, Decadal Ocean Heat Redistribution Since the Late 1990s and its Association with Key Climate Modes, *Climate*, Vol. 6, 91, 2019.

85. L. Cheng, J.P. Abraham, Z. Hausfather, and K.E. Trenberth, How fast are the oceans warming?, *Science*, Vol. 363, pp. 128-129, 2019. **Altmetric score = 2853, top 1%, January 2021, ranked 18 out of the top 30 papers in the field of Global Sustainabilty.**

86. J.P. Abraham, E.M. Sparrow, J.M. Gorman, Y. Zhao, and W.J. Minkowycz, Application of an Intermittency Model for Laminar, Transitional, and Turbulent Internal Flows, *Journal of Fluids Engineering*, Vol. 141, paper no. 071204, 2019.

87. J.P. Abraham, J. R. Stark, J.M. Gorman, E. M. Sparrow, W.J. Minkowycz, Tissue Burns Due to Contact Between a Skin Surface and Highly Conducting Metallic Media in the Presence of Inter-Tissue Boiling, *Burns*, Vol. 45, pp. 369-378, 2019.

88. J.M. Gorman, E. M. Sparrow, C.J. Smith, A. Ghoash, J.P. Abraham, R. Daneshfaraz, A. Rezazedeh Joudi, In-Bend Pressure Drop and Post-Bend Heat Transfer for a Bend with a Partial Blockage at its inlet, *Numerical Heat Transfer A*, Vol. 73, pp. 743-767, 2018.

89. A. Bahro, Z. Igyarto, C. Williams, J.P. Abraham, and B.J. Martinsen, Treatment of Critical Hand Schemia via Orbital Atherectomy and Focal Force Balloon Angioplasty: A Mini-Review, *Cardiovascular Revascularization Medicine*, Vol. 20, pp. 248-253, 2019.

2018

90. J.P. Abraham, R. Maki, Hydrodynamics of Laminar Flow Through Dimpled Pipes, *MOJ Civil Engineering*, Vol. 4, pp. 150-154, 2018.

91. L. Cheng, H. Luo, T. Boyer, R. Cowley, J. Abraham, V. Gouretski, F. Reseghetti, and J. Zhu, How Well Can We Correct Systematic Errors in Historical XBT Data? *Journal of Atmospheric and Oceanic Technology*, Vol. 35, pp. 1103-1125, 2018.

92. G. Wang, L. Cheng, J.P. Abraham, C. Li, Consensuses and Discrepancies of Basin-Scale Ocean Heat Content Changes in Different Ocean Analyses, *Climate Dynamics*, Vol. 50, pp. 2471-2487, 2018

93. R. Daneshfaraz, A.R. Joudi, J.P. Abraham, Numerical Investigation on the Effect of Sudden Contraction on Flow Behavior in a 90-Degree Bend, *Korean Journal of Civil Engineering*, Vol. 22, pp 603-612, 2018.

94. M. T. Sattari, A. Farkhondeh, and J.P. Abraham, Estimation of Sodium Adsorption Ratio Indicator Using Data Mining Methods: A Case Study in Urmia Lake Basin, Iran, *Environmental Science and Pollution Research*, Vol. 25, pp. 4776-4786, 2018.

95. M.T. Sattari, R. Misabbasi, R. S. Sushab, and J.P. Abraham, Prediction of Groundwater Level in the Ardebil Plain Using Support Vector Regression and the M5 Tree Model, *Groundwater Journal,* Vol. 56, pp. 636-646, 2018.

96. L. Cheng, K.E. Trenberth, J. T. Fasullo, J.P. Abraham, T.L. Boyer, K. von Schuckmann, and J. Zhu, Taking the Pulse of the Planet, *EOS,* Vol. 98, pp 14-15, 2018.

97. J.P. Abraham, B.D Plourde, L. J. Vallez, Comprehensive Review and Study of Buoyant Air Flow Within Positive-Pressure Hospital Operating Rooms, *Numerical Heat Transfer A*, Vol. 72, pp. 1-20, 2018.

98. M.R. Sattari, M. Pal, R. Mirabbasi, and J.P. Abraham, Ensemble of M5 Model Tree Based Modelling of Sodium Adsorption Ratio, *Journal of Artificial Intelligence and Data Mining*, Vol. 6, pp. 69-78, 2018.

2017

99. J.P. Abraham, A Global Warming Primer: Answering Your Questions about the Science, the Consequences, and the Solutions, *Physics Today*, Vol. 70, no. 3, 2017.

100. M.R. Sattari, Dodangeh, and J.P. Abraham, Estimation of Daily Soil Temperature Via Data Mining Techniques in Semi-Arid Climate Conditions, *Earth Sciences Research Journal*, Vol. 21, pp. 85-93, 2017.

101. J.P. Abraham, L. Cheng, M.E. Mann, Future Climate Projections Allow Engineering Planning, *Forensic Engineering*, Vol. 170, pp. 54-57, 2017.

102. B.D. Plourde, L.J. Vallez, B. B. Nelson-Cheeseman, J.P. Abraham, Transcutaneous Recharge: A Comparison of Numerical Simulation to In Vivo Experiments *Neuromodulation*, Vol. 20, pp. 613-621, 2017.

103. E.M. Sparrow, B.B Nelson-Cheeseman, W.J. Minkowycz, J.M. Gorman, and J.P. Abraham, Use of Multi-Lumen Catheters to Preserve Injected Stem Cell Viability and Injection Dispersion*, Cardiovascular Revascularization Medicine*, Vol. 18, pp. S49-S57, 2017.

104. L.J. Vallez, B.D. Plourde, J.E. Wentz, B. B. Nelson-Cheeseman, J.P. Abraham, A Review of Scald Burn Injuries, *Internal Medicine Review*, Vol. 3, pp. 1-18, 2017.

105. R. Daneshfaraz, H. Sadeghi, A. R. Joudi, J.P. Abraham, Experimental Investigation of Hydraulic Jump Characteristics in Contractions and Expansions, *Sigma Journal of Engineering and Natural Sciences*, Vol. 35, pp. 87-98, 2017.

106. R. Daneshfaraz, A. R. Joudi, A. Ghaderi, J.P. Abraham, Comparisons of CFD Simulations with Physical Models of Dam Spillway Flow (Case Study: Azad Dam Spillway, Iran), *Journal of Dams and Reservoirs*, (accepted).

107. L.J. Cheng, K.E. Trenberth, T. Boyer, J. T. Fasullo, L. Zhu, J.P. Abraham, Improved Estimates of Ocean Heat Content from 1960-2015, *Science Advances*, Vol. 4, paper no. e1601545, 2017. **Altmetric Score = 753, top 1%, January 2021.**

108. J.M. Gorman, E., M. Sparrow, J.P. Abraham, W.J. Minkowycz, Heat Transfer Design Methodology Treating a Heat Exchanger Device and its Fluid-Mover Partner as a Single System, *Heat Transfer Engineering*, Vol. 38, pp. 841-852, 2017.

109. R.T. Bourdon, B.B. Nelson-Cheeseman, and J.P. Abraham, Review on the Treatment and Avoidance of Scald Injuries, *World Journal of Dermatology*, Vol. 6, pp. 17-26, 2017.

2016

110. B.D. Plourde, J.R. Stark, J. P. Abraham, A New Catheter Technology to Deliver Vascular Stem-Cells, *Global Journal of Stem Cell Biology and Transplantation*, Vol. 2, pp. 7-16, 2016.

111. J.R. Stark, S.R. Romero, J.M. Gorman, J.P. Abraham, E.M. Sparrow, Modulated-Power Implantable Neuromodulation Devices and Their Impact on Surrounding Tissue Temperatures, *Journal of Biomedical Science and Engineering*, Vol. 9, pp. 545-562, 2016.

112. L. Cheng, K.E. Trenberth, M.D. Palmer, J. Zhu, and J.P. Abraham Observed and Simulated Full-Depth Ocean Heat Content Changes for 1970-2005, *Ocean Sciences*, Vol. 12, pp. 925-935, 2016.

113. J.M. Gorman, E.M. Sparrow, J.P. Abraham, W. J. Minkowycz, Evaluation of the Efficacy of Turbulence Models for Swirling Flows and Effect of Turbulence Intensity on Heat Transfer, *Numerical Heat Transfer B*, Vol. 70, pp. 485-502, 2016.

114. J.P. Abraham, B.B. Nelson Cheeseman, E. M. Sparrow, J.E. Wentz, J.M. Gorman, S. E. Wolf, Comprehensive Method to Predict and Quantify Scald Burns from Beverage Spills, *Int. J. Hyperthermia*, Vol. 32, pp. 900-910, 2016.

115. B.D. Plourde, L.J. Vallez, B. Sun, B.B. Nelson-Cheeseman, J.P. Abraham, Alterations of Blood Flow Through Arteries Following Atherectomy and the Impact on Pressure Variation and Velocity, *Cardiovascular Engineering and Technology*, Vol. 7, pp. 280-289, 2016.

116. N.K. Langat, T. Thorusa, J.P. Abraham, J. Wanyoko, Performance of an Improved Fluidized System for Processing Green Tea, *World Academy of Science Engineering and Technology*, Vol. 10, 1045-1050, 2016.

117. L. Cheng, J. Abraham, G. Goni, T. Boyer, S. Wijffels, R. Cowley, V. Gouretski, F. Reseghetti, S. Kizu, S. Dong, F. Bringas, M. Goes, L. Houpert, J. Sprintall, and J. Zhu, XBT Science: Assessment of XBT Biases and Errors, *Bulletin of the American Meteorological Society*, Vol. 97, pp. 924-933, 2016.

118. J.P. Abraham, R. Cowley, L. Cheng, Quantification of the Effect of Water Temperature on the Fall Rate of eXpendable BathyThermographs, *Journal of Atmospheric and Oceanic Technology*, Vol. 6, pp. 1271-1284, 2016.

119. R.T. Bourdon, B.B. Nelson-Cheeseman, and J.P. Abraham, Prediction, Identification, and Initial Treatment Guidelines for Scald Injuries, *Austin Journal of Emergency and Critical Care Medicine, Special Issue on Burns*, Vol. 3, pp. 1043-1049, 2016.

120. J.C.K. Tong, J.P. Abraham, J.M.Y. Tse, W.J. Minkowycz, and E.M. Sparrow, New Archive of Heat Transfer Coefficients from Square and Chamfered Cylinders in Crossflow, *International Journal of Thermal Sciences*, Vol. 105, pp. 218-223, 2016.

121. L. Cheng, K.E. Trenberth, M.D. Palmer, J. Zhu, and J.P. Abraham, Observed and Modeled Ocean Heat Content Changes Since 1970, *Ocean Sciences,* Vol 12, pp. 925-936, 2016.

122. R. Daneshfaraz, A. Ghahramanzadeh, A. Ghaderi, A. Rezazadeh Joudi, and J.P. Abraham, Investigation of the Effect of Edge Shape on Characteristics of Flow Under Vertical Gates, *Journal AWWA*, Vol. 8, pp. E425-432, 2016.

123. J.P. Abraham, B.D. Plourde, L.J. Vallez, and B.B. Nelson-Cheeseman, Correcting a Prevalent Misunderstanding of Burns, *Burns*, Vol. 42, pp. 715-716, 2016.

124. J. P. Abraham and B.D. Plourde, Validation of Numerically Simulated Tissue Temperatures During Transcutaneous Recharge of Neurostimulation Systems, *Journal of Neuromodulation*, Vol. 19, pp. 161-170. 2016.

125. L.J. Vallez, B.D. Plourde, and J.P. Abraham, A New Computational Thermal Model for the Whole Human Body: Applications to Patient Warming Blankets, *Numerical Heat Transfer A*, Vol. 69, pp. 227-241, 2016.

2015

126. J.P. Abraham, B.D. Plourde, B. Sun, L.J. Vallez, and C.S. Staniloae, The Effect of Plaque Removal on Pressure Drop and Flowrate Through a Stenotic Lesion*, Biology and Medicine,* Vol. 8, article no. 1000261, 2015.

127. L.J. Vallez, B. Sun, B.D. Plourde, J.P. Abraham, and C.S. Staniloae, Numerical Analysis of Arterial Plaque Thickness and its Impact on Artery Wall Compliance, *J. Cardiovascular Medicine and Cardiology*, Vol. 2, pp. 26-34, 2015.

128. D. Nguyen, J. M. Gorman, E.M. Sparrow, and J.P. Abraham, Convective Heat Transfer Enhancement Versus Disenhancement: Impact of Fluid-Mover Characteristics, *Applied Thermal Engineering,* Vol. 90, pp. 242-249, 2015.

129. B. Sun, L.J. Vallez, D.B. Plourde, J. R. Stark, and J.P. Abraham, Influence of Supporting Tissue on the Deformation and Compliance of Healthy and Diseased Arteries, *Journal of Biomedical Science and Engineering*, Vol. 8, pp. 490-499, 2015.

130. J.P. Abraham, B.D Plourde, L.J. Vallez, J.R. Stark, and K. R. Diller, Estimating the Time and Temperature Relationship for Causation of Deep-partial Thickness Skin Burns, *Burns*, Vol. 41, pp. 1741-1747, 2015.

131. G. Foster and J.P. Abraham, Lack of Evidence for a Slowdown in Global Temperature, US Climate Variability and Predictability Program (CLIVAR) Summer 2015, Vol. 13, pp. 6-9, 2015.

132. L. Cheng, J. Zhu, and J.P. Abraham, Global Upper Ocean Heat Content Estimation: Recent Progresses and the Remaining Challenges, *Atmospheric and Oceanic Science Letters*, Vol. 8, pp. 333-338, 2015.

133. M. Richardson, Z. Hausfather, D.A. Nuccitelli, K. Rice, and J.P. Abraham, Misdiagnosis of Earth Climate Sensitivity Based on Energy Balance Model Results, *Science Bulletin*, Vol. 60, pp. 1360-1377, 2015.

134. B.D. Plourde and J.P. Abraham, Design and Development of a New Cell Infusion Catheter, *World Biomedical Frontiers*, ISSN:2328-0166, 2015.

135. B.D. Plourde, J.P. Abraham, and W.J. Minkowycz, Continuous Flow Solar Thermal Pasteurization of Drinking Water: Methods, Devices, Microbiology, and Analysis, *Renewable Energy,* Vol. 81, pp. 795-803, 2015.

136. J.M. Gorman, M. Carideo, E.M. Sparrow, and J.P. Abraham, Heat Transfer and Pressure Drop Comparison of Louver- and Plain-finned Heat Exchangers Where One Fluid Passes Through Flattened Tubes, *Case Studies in Thermal Engineering,* Vol. 5, pp. 122-126, 2015.

137. J.C.K. Tong, J.P. Abraham, J.M.Y. Tse, and E.M. Sparrow, Impact of Chamfer Contours to Reduce Column Drag, *Engineering and Computational Mechanics*, Vol. 168, pp. 79-88, 2015.

138. D. Egbe, T. Mayah, E. Ebota, P. Egbe, J. Abraham, Performance Evaluation and Improvement on a Melon Seed Shelling Machine, *World Journal of Agricultural Sciences and Engineering*, Vol. 1, pp. 157-10, 2015.

139. A. Lundardelli, J.E. Wentz, J.P. Abraham, and B.D. Plourde, Shielding Nozzle Design and Analysis for Atomization-Based Cutting Fluid Systems in Micromachining, *ASME Journal of Micro- and Nano-Manufacturing*, Vol. 3, paper no. 024501, 2015.

140. N. Langat, T. Thoruwa, J. Wanyoko, J. Kiplagat, B.D Plourde, and J.P. Abraham, Models and Experiments for Energy Consumption and Quality of Green Tea Drying, *Energy Science and Engineering*, Vol. 3, 43-50, 2015.

141. T. Scambos and J.P. Abraham, Antarctic Ice Sheet Mass Loss and Future Sea Level Rise, *Forensic Engineering, Proceedings of the Institute of Civil Engineers*, Vol. 168, pp. 81-84, 2015.

142. J.P. Abraham, J.R. Stark, W.J. Minkowycz, Extreme weather: Observations of Precipitation Changes in the USA, *Forensic Engineering, Proceedings of the Institution of Civil Engineers*, Vol. 168, pp. 68-70, 2015.

2014

143. N. Dib, D.B. Schwalbach, B.D. Plourde, R.E. Kohler, D. Dana, and J.P. Abraham, Impact of Balloon Inflation Pressure on Cell Viability with Single and Multi Lumen Catheters, *Cardiovascular Translation Research*, Vol. 7, pp. 781-787, 2014.

144. J.P. Abraham, J.T. Fasullo, and G. Laden, Continued Global Warming in the Midst of Natural Climate Fluctuations, *Reports of the National Center for Science Communication*, 34(6), 2014.

145. N. Dib, J.P. Abraham, B.D. Plourde, D.B. Schwalbach, D. Dana, L. Myers, K. Hunkler, S.R. D'Silva, T.R. Flower, and R.E. Kohler, TCT-155 A Novel Multi Lumen Compliant Balloon Catheter (ND Infusion Catheter) Preserves Stem Cell Viability and Improves Dispersion When Compared to a Standard Single Lumen Balloon Angioplasty Catheter, *Journal American College of Cardiology*, Vol. 64, 11, 2014.

146. J.P. Abraham, B.D. Plourde, and J.R. Stark, Cryosurgical Treatment of Cancer: The Importance of Modeling, *Journal of Cancer Science and Therapy,* Vol. 6, 2014 (abstract).

147. J.P. Abraham, S. Kumar, B.R. Bickmore, and J.T. Fasullo, Issues Related to the Use of One-Dimensional Ocean Diffusion Models for Determining Climate Sensitivity, *Journal of Earth Science and Climate Change*, Vol. 5, paper 1000220, 2014.

148. T. Shepard, J.P. Abraham, D.S. Schwalbach, S. Kane, D. Sigling, and T. Harrington, Velocity and Density Effect on Impact Force During Water Entry of Spheres, *Journal of Geophysics and Remote Sensing*, Vol. 3, paper no. 1000129, 2014.

149. D.S. Schwalbach, T. Shepard, S. Kane, D. Siglin, T. Harrington, and J.P. Abraham, Effect of Impact Velocity and Mass Ratio During Vertical Sphere Water Entry, *Developments and Applications of Oceanic Engineering*, Vol. 3, 55-62, 2014.

150. J.P. Abraham, B.D. Plourde, J.R. Stark, and W.J. Minkowycz, Improvements to the Quality and Quantity of Ocean Heat Content Measurements, *Journal of Earth Science and Climate Change,* Vol. 5, pp. 100, 2014 (abstract).

151. J.P. Abraham, B.D. Plourde, and K.E. Trenberth, Closing Earth's Energy Balance, *Journal of Earth Science and Climate Change*, Vol. 5, pp. 69, 2014 (abstract).

152. J.M. Gorman, E.M. Sparrow, and J.P. Abraham, Temperature Determination by Means of Optoacoustic Measurements, *Studies in Engineering and Technology*, Vol. 1, 15-20, 2014.

153. J.M. Gorman, E.M. Sparrow, and J.P. Abraham, Slot Jet Impingement Heat Transfer in the Presence of Jet Axis Switching, *International Journal of Heat and Mass Transfer,* Vol. 78, 50-57, 2014.

154. J.P. Abraham, A review of the HANDY Study, *Cosmopolis*, Vol. 2014-1, pp. 8-87, 2014.

155. J.P. Abraham, Climate Change in the Midwest: Impacts, Risks, Vulnerabilities, and Adaptation. A Review of New Biological Books, *The Quarterly Review of Biology*, Vol. 89, pp. 171-172, 2014.

156. B.D. Plourde, D.B. Schwalbach, J.P. Abraham, and R.E. Kohler, Intracoronary Injection of Medication from Multi-lumen Injection Catheters, *Journal of Medical Devices,* Vol. 8, paper number 020901, 2014.

157. J.P. Abraham, J. Cook, J. T. Fasullo, P. H. Jacobs, S. A. Mandia, and D. A Nuccitelli, Review of the Consensus and Asymmetric Quality of Research on Human-Induced Climate Change, *Cosmopolis*, Vol. 2014-1, pp. 3-18, 2014.

158. B.L. Viglianti, M.W. Dewhirst, J.M. Gorman, and J.P. Abraham, E.M. Sparrow, Rationalization of Thermal Injury Quantification Methods: Application to Skin Burns, *Burns*, Vol. 40, pp. 896-902, 2014.

159. N.M. Naughton, B.D. Plourde, J.R. Stark, S. Hodis, and J. P. Abraham, Impacts of Waveforms on the Fluid Flow, Wall Shear Stress, and Flow Distribution in Cerebral Aneurysms and the Development of a Universal Reduced Pressure, *J. Biomedical Science and Engineering*, Vol. 7, 7-14, 2014.

160. J.M. Gorman, J.P. Abraham, D. B. Schwalbach, T. S. Shepard, J.R. Stark, and F. Reseghetti, Experimental Verification of Drag Forces on Spherical Objects Entering Water, *Journal of Marine Biology and Oceanography*, Vol. 3, paper no. 1000126, 2014.

161. S. Beacher, E.M. Sparrow, J.M. Gorman, and J.P. Abraham, Theory and Numerical Simulation in Thermochemical Ablation, *Numerical Heat Transfer Part A*, Vol. 66, pp. 131-143, 2014.

162. J.P. Abraham, J.M. Gorman, F. Reseghetti, E.M. Sparrow, J.R. Stark, and T.G. Shepard, Modeling and Numerical Simulation of the Forces Action on a Sphere During Early-Water Entry, *Ocean Engineering,* Vol. 76, 1-9, 2014.

163. J.M. Gorman, J.P. Abraham, and E.M. Sparrow, A Novel, Comprehensive Numerical Simulation for Predicting Temperatures Within Boreholes and the Adjoining Rock Bed, *Geothermics*, Vol. 50, pp. 213-219, 2014.

2013

164. J.P. Abraham, B.D. Plourde, G.S. Mowry, and E.M. Sparrow, Experimental Test of Multi-Stage Vertical Axis Turbines for Cellular Communication Applications, *ASME Proceedings,* Paper Number ES2012-91025, pp. 1333-1339, 2013.

165. D.B. Schwalbach, B.D. Plourde, J.P. Abraham, and R.E. Kohler, Drug Dispersion for Single- and Multi-Lumen Catheters, *Journal of Biomedical Science and Engineering*, Vol. 6, pp. 1021-1028, 2013.

166. N. Dib, R.E. Kohler, J.P. Abraham, B.D. Plourde, D.B. Schwalbach, D. Dana, B.J. Baird, T.R. Flower, L. Myers, and K. Hunkler, TCT-811 Stem Cell Viabilitiy Significantly Reduced After Passing Through a Standard Single Lumen Over-the-Wire 0.014 Balloon Angioplasty Cather, *Journal of the American College of Cardiology*, Vol. 62, B246, 2013.

167. D.A. Nuccitelli, J.P. Abraham, R.E. Benestad, and S.A. Mandia, Comment on: Akasofu, S.-I. On The Present Halting of Global Warming, *Climate*, Vol. 1, pp. 76-83, 2013.

168. J.M. Gorman, E. M. Sparrow, and J.P. Abraham, Differences Between Measured Pipe Wall Surface Temperatures and Internal Fluid Temperatures, *Case Studies in Thermal Engineering,* Vol. 1, 13-16, 2013.

169. J.R. Stark, J.M. Gorman, E.M. Sparrow, J.P. Abraham, and R.E. Kohler, Controlling the Rate of Penetration of a Therapeutic Drug Into the Wall of an Artery by Means of a Pressurized Balloon, *Journal of Biomedical Science and Engineering*, Vol. 6, pp. 527-532, 2013.

170. J.P. Abraham, M. Baringer, N.L. Bindoff, T. Boyer, L.J. Cheng, J.A. Church, J.L. Conroy, C.M. Domingues, J.T. Fasullo, J. Gilson, G. Goni, S.A. Good, J. M. Gorman, V. Gouretski, M. Ishii, G.C. Johnson, S. Kizu, J.M. Lyman, A. M. Macdonald, W.J. Minkowycz, S.E. Moffitt, M.D. Palmer, A.R. Piola, F. Reseghetti, K. Schuckmann,K.E. Trenberth, I. Velicogna, and J.K. Willis, A Review of Global Ocean Temperature Observations: Implications for Ocean Heat Content Estimates and Climate Change, *Reviews of Geophysics*, Vol. 51, pp 450-483, 2013. **Altmetric score = 173, top 5%, January 2021.**

171. J.P. Abraham, J.R. Stark, J.M. Gorman, E.M. Sparrow, and R.E. Kohler, A Model of Drug Deposition Within Artery Walls, *J. Medical Devices*, Vol. 7, paper no. 020902, 2013.

172. E.M. Sparrow, N.T. Littlejohn, J.M. Gorman, and J.P. Abraham, Mass Transfer and Particle Separation by Swirl-Chamber and Swirl-Tube Devices, *Numerical Heat Transfer A,* Vol. 64, 611-620, 2013.

173. E.M. Sparrow, J. M. Gorman, and J.P. Abraham, Quantitative Assessment of the Overall Heat Transfer Coefficient U, *Journal of Heat Transfer*, Vol. 135, paper no. 061102, 2013.

174. J.P. Abraham, E.M. Sparrow, J.M. Gorman, J.R. Stark, and R. E. Kohler, A Mass Transfer Model of Temporal Drug Deposition in Artery Walls, *International Journal of Heat and Mass Transfer*, Vol. 58, pp. 632-638, 2013.

175. R.R. Rend, E. M. Sparrow, D. W. Bettenhausen, and J. P. Abraham, Parasitic Pressure Losses in Diffusers and in Their Downstream Piping Systems for Fluid Flow and Heat Transfer, *International Journal of Heat and Mass Transfer*, Vol. 61, pp. 56-61, 2013.

2012

176. E.M. Sparrow, J.M. Gorman, K.S. Friend, and J.P. Abraham, Flow Regime Determination for Finned Heat Exchanger Surfaces with Dimples/Protrusions, *Numerical Heat Transfer*, Vol. 63, pp. 245-256, 2012.

177. B.D. Plourde, J.P. Abraham, G.S. Mowry, and W.J. Minkowycz, Simulations of Three-Dimensional Vertical-Axis Turbines for Communications Applications, *Wind Engineering*, Vol. 36, pp. 443-454, 2012.

178. J.P. Abraham, B.D. Plourde, G.S. Mowry, and W.J. Minkowycz, Summary of Savonius Wind Turbine Development and Future Applications for Small-Scale Power Generation, *Journal of Renewable and Sustainable Energy*, Vol. 4, paper no. 042703, 2012.

179. J.M. Gorman, EM. Sparrow, J.P. Abraham, and G.S. Mowry, Operating Characteristics and Fabrication of a Uniquely Compact Helical Heat Exchanger, *Applied Thermal Engineering*, Vol. 5, pp. 1070-1075, 2012.

180. E.M. Sparrow, J.M. Gorman, A. Trawick, and J.P. Abraham, Novel Techniques for Measurements of Thermal Conductivity of Both Highly and Lowly Conducting Media, *International Journal of Heat and Mass Transfer*, Vol. 55, pp. 4037-4042, 2012.

181. J.P. Abraham, J.M. Gorman, F. Reseghetti, E.M. Sparrow, and W.J. Minkowycz, Drag Coefficients for Rotating Expendable Bathythermographs and the Impact of Launch Parameters on Depth Predictions, *Numerical Heat Transfer A*, Vol. 62, pp. 25-43, 2012.

182. M. Nelson and J.P. Abraham, Hemodynamics of AV Grafts for Hemodialysis Access, *Journal of Medical Devices,* Vol. 6, article no. 017553, 2012.

183. J.P. Abraham and J. Jeske, Cryosurgical Simulations for Ablation of Kidney Tumors, *Journal of Medical Devices,* Vol. 6, article no 017504, 2012.

184. J.P. Abraham, J.M. Gorman, F. Reseghetti, W.J. Minkowycz, and E. M. Sparrow, Turbulent and Transitional Modeling of Drag on Oceanographic Measurement Devices, *Computational Fluid Dynamics and its Applications* 2012, article ID 567864, doi:10.1155/2012/567864.

2011

185. J.P. Abraham, J.M. Gorman, F. Reseghetti, K.E. Trenberth, and W.J. Minkowycz, A New Method of Calculating Ocean Temperatures Using Expendable Bathythermographs*, Energy and Environment Research*, Vol. 1, pp. 2-11, 2011.

186. J.R. Stark, J.M. Gorman, M.P. Hennessey, F. Reseghetti, J. Willis, J. Lyman, J.P. Abraham, and M. Borghini, A Computational Method for Determining XBT Depths, *Ocean Sciences*, Vol. 7, pp. 733-743, 2011.

187. B.D. Plourde, J. P. Abraham, G.S. Mowry, and W.J. Minkowycz, Use of Small-Scale Wind Energy to Power Cellular Communication Equipment, *Sensors and Transducers*, Vol. 13, pp. 53-61, 2011.

188. J.P. Gorman, E.M. Sparrow, G.S. Mowry, and J.P. Abraham, Simulation of Helically Wrapped, Compact Heat Exchangers, *Journal of Renewable and Sustainable Energy*, Vol. 3, article no. 043120, 2011.

189. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Surrogate Human Tissue Temperatures Resulting from Misalignment of Antenna and Implant During Recharging of a Neuromodulation Device, *Journal of Neuromodulation*, Vol. 14, pp. 501-511, 2011.

190. K.E. Trenberth, J.T Fasullo, and J.P. Abraham, Issues in Establishing Climate Senstivity in Recent Studies, *Remote Sensing,* Vol. 3, pp. 2051-2055, 2011.

191. R.D. Lovik, E. M. Sparrow, J. P. Abraham, C. Zelmer, S. Oh, K. Friend, and D. K. Smith, Effect of Component Misalignment on Human Tissue Temperatures Associated with Recharged Nueromodulation Devices, *Journal of Medical Devices*, Vol. 5, 0207516, 2011.

192. T. Gebreegziabher, E.M. Sparrow, J.P. Abraham, E. Ayorinde, and T. Singh, High-Frequency Pulsatile Pipe Flows Encompassing All Flow Regimes, *Numerical Heat Transfer A*, Vol. 60, pp. 811-826, 2011.

193. J.P. Abraham, M.P. Hennessey, and W.J. Minkowycz A Simple Algebraic Model to Predict Burn Depth and Injury, *International Communications in Heat and Mass Transfer*, Vol. 38, pp. 1169-1171, 2011.

194. J.P. Abraham, B.D. Plourde, G.S. Mowry, E. M. Sparrow, and W.J. Minkowycz, Numerical Simulation of Fluid Flow Around a Vertical-Axis Turbine, *Journal of Renewable and Sustainable Energy*, Vol. 3, article no. 033109, 2011 (doi:10.1063/1.3588037).

195. B.M. Osende, J.P. Abraham, and G.S. Mowry, Small-Scale Use of Solar Power in Remote, Developing Regions: A Case Study, *Journal of Sustainable Development,* Vol. 4, pp. 3-9, 2011.

196. B.D. Plourde, J. P. Abraham, G. S. Mowry, and W. J. Minkowycz, An Experimental Investigation of a Large, Vertical-Axis Wind Turbine: Effects of Venting and Capping, *Wind Engineering,* Vol. 35, pp. 213-220, 2011.

197. N.N. Johnson, J.P. Abraham, Z.I. Helgeson, W.J. Minkowycz, and E. M. Sparrow, An Archive of Skin-Layer Thicknesses and Properties and Calculations of Scald Burns with Comparisons to Experimental Observations, *Journal of Thermal Science and Engineering Applications*, Vol. 3, paper no. 011003, 2011.

198. Z. Helgeson, J. Jenkins, J. Abraham, and E. Sparrow, Particle Trajectories and Agglomeration/Accumulation in Branching Arteries Subjected to Orbital Atherectomy, *Open Biomedical Engineering Journal*, Vol. 5, pp. 25-38, 2011.

199. L. Steck, E.M. Sparrow, and J.P. Abraham, Non-Invasive Measurement of the Human Core Temperature, *International Journal of Heat and Mass Transfer*, Vol. 54, pp. 949-982, 2011.

200. N. N. Johnson, J. P. Abraham, Z, I. Helgeson and M.P. Hennessey, Simulation of Embolization Particle Trajectories, *Frontiers in Heat Transfer*, Vol. 2, paper no. 023006, 2011.

201. G. Adams, P. Khanna, C. Staniloae, J.P. Abraham, and E.M. Sparrow, Optimal Techniques with the Diamondback 360 System Achieve Effective Results for the Treatment of Peripheral Arterial Disease, *Journal of Cardiovascular Translation Research*, Vol. 4, 220-229, 2011.

202. J.P. Abraham, E. M. Sparrow, and W. J. Minkowycz, Internal-Flow Nusselt Numbers for the Low-Reynolds-Number End of the Laminar-to-Turbulent Transition Regime, *International Journal of Heat and Mass Transfer*, Vol. 54, 584-588, 2011.

203. S. Chelikani, E.M. Sparrow, J.P. Abraham, and W.M. Minkowycz, Mass Transfer in Vascular Access Ports*, International Journal of Heat and Mass Transfer*, Vol. 54, pp. 949-958, 2011.

2010

204. R. Ramazani-Red, S. Chelikani, E. M. Sparrow, and J. P. Abraham, Experimental and Numerical Investigation of Orbital Atherectomy: Absence of Cavitation, *Journal of Biomedical Science and Engineering*, Vol. 3, pp. 1108-1116, 2010.

205. A.P. Thomas and J.P. Abraham, Sawtooth Vortex Generators for Underwater Propulsion, *Open Mechanical Engineering*, Vol. 4, pp. 1-7, 2010.

206. D. K. Smith, R.D. Lovik E. M. Sparrow, and J. P. Abraham, Human Tissue Temperatures Achieved During Recharging of New-Generation Neuromodulation Devices, *International Journal of Heat and Mass Transfer,* Vol. 53, 3292-3299, 2010.

207. J. P. Abraham, E. M. Sparrow, J. C. K. Tong, and D. W. Bettenhausen, Internal Flows which Transist from Turbulent Through Intermittent to Laminar, *International Journal of Thermal Sciences*, Vol. 49, 256-263, 2010.

208. E.M. Sparrow, J.P. Abraham, Y. Bayazit, R.D. Lovik, and D.K. Smith, Numerical and Experimental Simulations as Symbiotic Tools for Solving Complex Biothermal Problems, *Journal of Medical Devices*, Vol. 4, 027536, 2010.

2009

209. R.D. Lovik, J.P. Abraham, W.J. Minkowycz, and E.M. Sparrow, Laminarization and Turbulentization in a Pulsatile Pipe Flow, *Numerical Heat Transfer Part A*, Vol. 56, 861-879, 2009.

210. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Tissue-Damage Potential from Transcutaneous Recharge of Neuromodulation Implants, *International Journal of Heat and Mass Transfer*, Vol. 52, pp. 3518-3524, 2009.

211. E.M. Sparrow, J.P. Abraham, and W.J. Minkowycz, Flow Separation in a Diverging Conical Duct: Effect of Reynolds Number and Divergence Angle, *International Journal of Heat and Mass Transfer,* Vol. 52, pp. 3079-3083, 2009.

212. F.A. Hoover and J.P. Abraham, A Comparison of Corn-Based Ethanol with Cellulosic Ethanol as Replacements for Petroleum-Based Fuels, A Review*, International Journal of Sustainable Energy*, Vol. 28, pp. 171-182, 2009.

213. G.S. Mowry, R. Erickson, and J.P. Abraham, Computational Model of a Novel, Two-Cup Horizontal Wind-Turbine System, *Open Mechanical Engineering Journal*, Vol. 3, pp. 26-34, 2009.

214. J.C.K. Tong, E.M. Sparrow, and J. P. Abraham, Geometric Strategies for Attainment of the Identical Outflows Through all of the Exit Ports of a Distribution Manifold in a Manifold System, *Applied Thermal Engineering*, Vol. 29, 3552-3560, 2009.

215. W.J. Minkowycz, J.P. Abraham, and E.M. Sparrow, Numerical Simulation of Laminar Breakdown and Subsequent Intermittent and Turbulent Flow in Parallel Plate Channels: Effects of Inlet Velocity Profile and Turbulence Intensity, *International Journal of Heat and Mass Transfer*, 52, pp. 4040-4046, 2009.

216. J.P. Abraham, G.S. Mowry, R. Erickson, Analysis of Urban Wind Turbines, Clean Technology, pp. 13-16, 2009.

217. J.P. Abraham and A.P. Thomas, Induced Co-Flow and Laminar-to-Turbulent Transition with Synthetic Jets, *Computers and Fluids*, Vol. 38, pp. 1011-1017, 2009.

218. J.P. Abraham, E.M. Sparrow, and J.C.K. Tong, Heat Transfer in All Pipe Flow Regimes - Laminar, Transitional/Intermittent, and Turbulent, *International Journal of Heat and Mass Transfer,* Vol. 52, pp. 557-563, 2009.

2008

219. J.C. Tong, E.M. Sparrow, and J.P. Abraham, Unified Treatment of Natural Convection in Tall, Narrow, and Flat, Wide Rectangular Channels, *Numerical Heat Transfer A*, Vol. 54, pp. 763-776, 2008.

220. J.P. Abraham, J.C.K. Tong, and E.M. Sparrow, Breakdown of Laminar Pipe Flow into Transitional Intermittency and Subsequent Attainment of Fully Developed Intermittent or Turbulent Flow, *Numerical Heat Transfer B*, Vol. 54, pp. 103-115, 2008.

221. J.P. Abraham, E.M. Sparrow, and R.D. Lovik, Unsteady, Three-Dimensional Fluid Mechanic Analysis of Blood Flow in Plaque-Narrowed and Plaque-Free Arteries, *International Journal of Heat and Mass Transfer*, Vol. 51, 5633-5641, 2008.

222. E.M. Sparrow, J.C.K. Tong, and J.P. Abraham, Fluid Flow in a System with Separate Laminar and Turbulent Zones, *Numerical Heat Transfer A*, Vol. 53 (4), pp. 341-353, 2008.

2007

223. J.P. Abraham and C.M. George, Full-Building Radiation Shielding for Climate Control in Desert Regions, *International Journal of Sustainable Energy*, Vol. 26 (3) pp. 167-177, 2007.

224. J.P. Abraham and E.M. Sparrow, A Thermal Ablation Model Including Liquid-to-Vapor Phase Change, Necrosis-Dependent Perfusion, and Moisture-Dependent Properties, *International Journal Heat and Mass Transfer*, Vol. 50, pp. 2537-2544, 2007.

225. J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, Attainment of Flowrate Uniformity in the Channels that Link a Distribution Manifold to a Collection Manifold*, Journal of Fluids Engineering*, Vol. 129 (9), pp. 1186-1192, 2007.

226. E.M. Sparrow and J.P. Abraham, A Simulation of Gas-Based, Endometrial-Ablation Therapy for the Treatment of Menorrhagia, *Annals of Biomedical Engineering,* Vol. 36 (1), pp. 171-183, 2008

2007

227. J.P. Abraham, E.M. Sparrow, and S. Ramadhyani, Numerical Simulation of a BPH Thermal Therapy – A Case Study Involving TUMT, *Journal of Biomechanical Engineering*, Vol. 129, pp. 548-557, 2007.

228. J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, A Quasi-Analytical Method for Fluid Flow in a Multi-Inlet Collection Manifold, *Journal of Fluids Engineering*, Vol. 129, pp. 579-586, 2007.

229. J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, Numerical Simulation of the Urine Flow in a Stented Ureter, *Journal of Biomechanical Engineering*, Vol. 129, pp. 187-192, 2007.

2006

230. J.P. Abraham, A Guide to Curing Processes, *Journal of Precision Manufacturing*, 6, pp. 16-17, 2006.

231. J.P. Abraham and C.M. George, Micro-Geothermal Devices for Low-Energy Air-Conditioning in Desert Climates, *GHC Bull.*, Vol. 27, (4), pp. 13-16, 2006.

232. P.W. Chevalier, J.P. Abraham, and E.M. Sparrow, The Design of Cold Plates for the Thermal Management of Electronic Equipment, *Journal of Heat Transfer Engineering*, Vol. 27, pp. 6-16, 2006.

2005

233. E. M. Sparrow and J. P. Abraham, Universal Solutions for the Streamwise Variation of the Temperature of a Moving Sheet in the Presence of a Moving Fluid, *International Journal of Heat and Mass Transfer*, Vol. 48, pp. 3047-3056, 2005.

234. **E.M. Sparrow, J.P. Abraham, P.W. Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, *Journal of Heat Transfer*, Vol. 127, pp. 27-33, 2005.**

235. J. P. Abraham and E. M. Sparrow, Friction Drag Resulting From the Simultaneous Imposed Motion of a Freestream and its Bounding Surface, *International Journal of Heat and Fluid Flow*, Vol. 26, pp. 289-295, 2005.

236. S.K. S. Boetcher, E.M. Sparrow, and J.P. Abraham, Numerical Simulation of the Radiative Heating of a Moving Sheet, *Numerical Heat Transfer*, Vol. 47, pp. 1-25, 2005.

2004

237. E.M. Sparrow, J.P. Abraham, and J.C. K. Tong, Archival Correlations for Average Heat Transfer Coefficients for Non-Circular and Circular Cylinders and for Spheres in Crossflow, *International Journal of Heat and Mass Transfer*, Vol. 47 (24), pp. 5285-5296, 2004.

238. J.P. Abraham and E.M. Sparrow, A Simple Model and Validating Experiments for Predicting the Heat Transfer to a Load Situated in an Electrically Heated Oven, *Journal of Food Engineering*, Vol. 62 (4) pp. 409-415, 2004.

239. **J.P. Abraham, Teaching Case Studies to a Multi-Disciplinary Class - Bridging the Gap Between Engineering and the Biological Sciences, *Journal of College Science Teaching*, Vol. 33 (5), March/April 2004.**

2003

240. E.M. Sparrow and J.P. Abraham, A Computational Analysis of the Radiative and Convective Processes Which Take Place in Preheated and Non-Preheated Ovens, *Journal of Heat Transfer Engineering*, Vol. 24, No. 5, pp. 25-37, 2003.

241. J.P. Abraham and E.M. Sparrow, Three Dimensional Laminar and Turbulent Natural Convection in a Continuously/Discretely Wall-Heated Enclosure Containing a Thermal Load, *Numerical Heat Transfer, A,* Vol. 44, pp. 105-125, 2003.

242. E. M. Sparrow and J. P. Abraham, A New Buoyancy Model Replacing the Standard Pseudo-Density Difference for Internal Natural Convection in Gases, *International Journal of Heat and Mass Transfer*, Vol. 46, pp. 3583-3591, 2003.

2002

243. J.P. Abraham and E.M. Sparrow, Experiments on discretely heated, vented/unvented enclosures for various radiation surface characteristics of the thermal load, enclosure temperature sensor, and enclosure walls*, International Journal of Heat and Mass Transfer*, Vol. 45, pp. 2255-2263, 2002.

244. J.P. Abraham and E.M. Sparrow, Fluid Flow and Heat Transfer in Multiply-Folded, Continuous Flow Passages Including Conjugate Thermal Interaction Between the Fluid and Bounding Walls, *Numerical Heat Transfer, A*, Vol. 42, pp. 327-344, 2002.

245. E.M. Sparrow, J.P. Abraham, and Molly K. Rolfsmeier, Fabric Ducts for Air Distribution and for Décor, *Fabric Architecture*, March/April 2002.

246. E.M. Sparrow and J.P. Abraham, Heat Transfer Coefficients and Other Performance Parameters for Variously Positioned and Supported Thermal Loads in Ovens With/Without Water-Filled or Empty Blockages, *International Journal of Heat and Mass Transfer*, Vol. 45, pp. 3597-3607, 2002.

2001

247. E.M. Sparrow, J.C.K. Tong, and J.P. Abraham, An Experimental Investigation on a Mass Exchanger for Transferring Water Vapor and Inhibiting the Transfer of Other Gases*, International Journal of Heat and Mass Transfer*, Vol. 44, pp. 4313-4321, 2001.

248. E.M. Sparrow, G.L. Martin, J.P. Abraham, and J.C.K. Tong, Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance, *Transactions of the ASHRAE*, Vol. 107, (2) 2001.

Conference Presentations and Public Lectures (146 presentations)

1. L. Cheng, and J.P. Abraham, Perspectives on Ocean sand Their Role in the Global Energy Budget and Water Cycle, *American Meteorological Society 102nd Annual Meeting, Houston, Kevin Trenberth Symposium,* January 23-27, 2022 (invited).

2. L. E. Olsen and J.P. Abraham, New correlations for convective coefficients over square and cubical bodies, *48th National Conference on fluid mechanics and fluid power,* December 27-29, 2021.

3. D. Vishwakarma, S. Bhattacharyya, M. Soni and J.P. Abraham, Effect of Inlet Flat Obstructon on Thermohydraulic Characteristics in a Smooth Circular Tube in the Transition Flow Regime, *48th National Conference on fluid mechanics and fluid power,* December 27-29, 2021.

4. J.P. Abraham, Introduction to the Computational Tools Available in Fluid Mechanics and Heat Transfer Research, *National Workshop on Research Methodology in Fluid Mechanics,* Pilani, India, June 7-9, 2021.

5. L. Cheng, K. Trenberth, N. Gruber, M.E. Mann, J.P. Abraham, and J. Fasullo, Improved Estimates of Changes in Upper Ocean Salinity and Water Cycle, *AGU Fall Meeting*, 2020.

6. J.P. Abraham, The Science of Global Warming – What do we really know? *Presented at New Mexico Tech. Lecture Series*, September 24, 2020.

7. L. Cheng, K. Trenberth, K. von Schukmann, J.P. Abraham, V. Gouretski, Oceanic Responses to the Climate: Recognizing Changes and Extremes, *AAAS Annual Meeting*, February 11, 2021.

8. J.P. Abraham, Advanced Methods in Thermal Engineering, *International Workshop on Recent Advances in Thermal Engineering*, India, June 29-July 3, 2020.

9. J.P. Abraham, L. Cheng, Kevin Trenberth – A Life of Research and Impact, *Trenberth Symposium*, Denver, CO, March 16, 2020.

10. J.P. Abraham, Modern Climate Change, *Threats to the Worlds Oceans – World Ocean Day*, Minneapolis, MN June 8, 2020.

11. L. Cheng, K.E. Trenberth, N. Gruber, M.E. Mann, J.P. Abraham, J. Fasullo, G. Li, X. Zaho, and J. Zhu, Ocean Subsurface Salinity Changes Yield an Anthropogenic Climate Change Signal, *Ocean Sciences 2020*, San Diego, CA, February 16-21, 2020.

12. J.P. Abraham, Climate Science, Projections for the Next Two Decades, *Code Blue, Health Care Professionals for a Healthy Climate*, Minneapolis, MN, April 4, 2020.

13. L. Cheng, G. Foster, Z. Hausfather, K.E. Trenberth, J.P. Abraham, Increase in the Rate of Ocean Warming, *2019 AGU Fall Meeting*, San Francisco, December, 9-13, 2019.

14. J.P. Abraham, G. Foster, Z. Hausfather, L. Cheng, K.E. Trenberth, Earth's Energy Imbalance abd Energy Flows Through the Climate System, *2019 AGU Fall Meeting*, San Francisco, December, 9-13, 2019.

15. L. E. Olsen and J.P. Abraham, Evaluation of CFD algorithms for solving a canonical problem of flow over a square cylinder, *4th Thermal and Fluids Engineering Conference*, Las Vegas, April 14-17, 2019.

16. S. A. Mandia, J.P. Abraham, M. Ashley, and J.W. Dash, The Climate Rapid Response Team – An Effective Model for Engaging Media and Polictmakers, *2018 AGU Fall Meeting*, Washington, DC, December 2018.

17. J.P. Abraham, Climate Change, the Evidence is in the Oceans, *Presented at the National Laboratory for Marine Science and Technology*, Qingdao, China, October 25, 2018.

18. J.P. Abraham, Progress in XBT simulations, *Presented at the Institute of Atmospheric Physics*, Beijing, October 23, 2018.

19. J.P. Abraham, B.D. Plourde, J.R. Stark, Modeling Hemodynamics Through Lesions *Cardiovascular Research Technologies Conference 18*, Washington DC., March 3-6, 2018.

20. G. Wang, L. Cheng, J.P. Abraham, C. Li, and H. Du, Consensuses and discrepancies of basin-scale ocean heat content changes in different ocean analysis, *AOGS 15th Annual Meeting*, June 3-8, Hawaii, USA, 2018.

21. K.E. Trenberth, C. Lijing, P. Jacobs, and J.P. Abraham, Are recent hurricane (Harvey, Irma, and Maria) disasters Natural? *AGU Fall 2017 Meeting*, New Orleans, December 11-15, 2017.

22. P. Jacobs, S. Akella, K.E. Trenberth, C. Lijing, and J.P. Abraham, The Historical Context of the 2017 Hurricane Season's Ocean Warmth, *AGU Fall 2017 Meeting*, New Orleans, December 11-15, 2017.

23. J.P. Abraham, P. Jacobs, L. Cheng, K.E. Trenberth, Are recent hurricane (Harvey, Irma, and Maria) disasters Natural? *AGU Fall 2017 Meeting*, New Orleans, December 11-15, 2017.

24. J.P. Abraham and B.D. Plourde, Using ANSYS for Multiphysics Design of a Water Treatment System, *ANSYS Innovation Conference 2017*, Minneapolis, MN, November 8, 2017.

25. J.P. Abraham, L.J. Cheng, K.E. Trenberth, Improved Estimates of Ocean Heat Content from 19602015, *NOAA Presentation*, Washington DC, June 22, 2017.

26. J.P. Abraham, Use of Computational Fluid Dynamics to Improve Oceanographic Measurements, *NOAA Presentation*, Washington DC, January 12, 2017.

27. J.P. Abraham, B.D. Plourde, Use of Multi-lumen Catheters to Preserve Injected Stem Cell Viability, *Cardiovascular Research Technologies Conference 17*, Washington DC., February 18-21, 2017.

28. L. Cheng, J. Zhu, K. Trenberth, J. Fasullo, M. Palmer, T. Boyer, J. Abraham, Improved Ocean Heat Content Estimation Since 1960, *AGU Fall Meeting 2016*, San Francisco, CA, 2016.

29. J.P. Abraham, B. D. Plourde, John Stark, L.J. Vallez, Using ANSYS to Reduce Costs and Speed Development Process, *ANSYS Upper Midwest Innovation Conference*, Bloomington, Minnesota, November 17, 2016 (Keynote).

30. N. Langat, T. Thoruwa, J. Abraham, J. Wanyoko, Performance of an Improved Fluidized System for Processing Green Tea, *ICEE 18th International Conference on Energy Engineering*, Toronto, Canada, 2016.

31. L. Cheng, R. Cowley. J.P. Abraham, Cold Water Biases in XBT Descent, *5th XBT Science Workshop*, Tokyo, Japan, October 3-7, 2016 (Invited).

32. L. Cheng, K. Trenberth, M. Palmer, J.P. Abraham, Historical Ocean Heat Content Estimation and the Implications for Assessing Historical Earth's Energy Budget, *Clivar 2016*, Qingdao, China, 2016.

33. R. Cowley, J.P. Abraham, L. Cheng, The Effect of Water Temperature on XBT Fall Rate, *Clivar Third IQuOD Workshop,* Hamburg, Germany, December 3-4, 2015.

34. R. Cowley, L. Cheng, G. Goni, T. Boyer, J.P. Abraham, S. Wijffels, V. Gouretski, F. Reseghetti, S. Kizu, S. Dong, F. Bringas, M. Goes, L. Houpert, J. Sprintall, J. Zhu, Towards Reducing Uncertainty in Historical XBT Data: An International Effort from the XBT Science Team, *2016 Ocean Sciences Meeting*, New Orleans, LA, February 21-26, 2016.

35. J.P. Abraham and B.D. Plourde, Novel Cost-Effective Solution for Potable Water in All Environments, *The Food-Energy-Water Nexus, 16th National Conference and Global Forum on Science, Policy, and the Environment*, Washington DC, January 18-21, 2016.

36. J.P. Abraham and B.D. Plourde, Off-Grid Wind Power Systems for the Developing World, *The Food-Energy-Water Nexus, 16th National Conference and Global Forum on Science, Policy, and the Environment*, Washington DC, January 18-21, 2016.

37. L.Cheng, J. Zhu, J.P. Abraham, An Updated Historical (1970-2014) Upper OHC Estimates and Implication for the Global Energy Budget, *Climate and Ocean Variability and Change (CLIVAR) 8th Session of the Global Synthesis*, Exeter, UK, September 28, 2015.

38. J.P. Abraham, Our Changing Climate, *Citizens Climate Lobby Conference*, Red Wing, MN, November 6, 2015.

39. J.P. Abraham, J.R. Stark, Advances in XBT Measurement and Bias Reduction, *Chinese Academy of Sciences*, Beijing, October 10, 2015.

40. G. Foster and J.P. Abraham, Lack of Evidence for a Slowdown in Global Temperature, *American Geophysical Union Fall Meeting*, San Francisco, CA, December 14-18, 2015.

41. L. Cheng, J. Zhu, and J.P. Abraham, An Updated Estimate on Global Upper Ocean Heat Content Change and the Remaining Challenges, *American Geophysical Union Fall Meeting*, San Francisco, CA, December 14-18, 2015.

42. G. Foster and J.P. Abraham, Lack of Evidence for a Slowdown in Global Temperature, *US Climate Variability and Predictability Program (CLIVAR) Summit*, Tucson, AZ, August 4-6, 2015.

43. J.P. Abraham, Small-scale Wind Turbines: Design, Analysis and Applications, *Hong Kong University*, January 28, 2015 (invited).

44. J.P. Abraham, The Science of Climate Change, What Do We Really Know, *Hong Kong University of Science and Technolog*y, January 26, 2015 (invited).

45. J.P. Abraham et al., A Novel Multi Lumen Compliant Balloon Catheter (ND® Infusion Catheter) Preserves Stem Cell Viability and Improves Dispersion When Compared to a Standard Single Lumen Balloon Angioplasty Catheter, *European Society of Cardiology*, 2015, (submitted).

46. J.P. Abraham, T.M. Shepard, W.J. Minkowycz, J.R. Stark, J. M. Gorman, Quantification of Near-Surface Impact Forces on XBTs, *The 4th XBT Workshop: XBT Science and the Way Forward,* Beijing, China, November 11-13, 2014.

47. J.P. Abraham, B.D. Plourde, S.A. Mandia, and K.E. Trenberth, Closing the Earth Energy Imbalance, *3rd International Conference on Earth Science and Climate Change,* San Francisco, CA, July 28-30, 2014.

48. J.P. Abraham, B.D. Plourde, J.R. Stark, and W.J. Minkowycz, Improvements to the Quality and Quantity of Ocean Heat Content Measurements, *3rd International Conference on Earth Science and Climate Change,* San Francisco, CA, July 28-30, 2014.

49. J.P. Abraham, B.D. Plourde, J.R. Stark, W.J. Minkowycz, Cryosurgical Treatment of Cancer: The Importance of Modeling, *4th World Congress on Cancer Science and Therapy*, Chicago, October 20-22, 2014.

50. N. Dib, J.P. Abraham, B. D. Plourde, D.B. Schwalbach, D. Dana, L. Myers, K. Hunkler, T. Flower, and R.E. Kohler, A Novel Multi-lumen Compliant Balloon Catheter Preserves Stem Cell Viability and Decreases Cellular Clumping When Compared to a Standard Single-lumen Balloon Angioplasty Catheter, *Transcatheter Cardiovascular Therapeutics (TCT 2014)*, Washington, DC, September 13-17, 2014.

51. N. Dib, J.P. Abraham, B. D. Plourde, D.B. Schwalbach, D. Dana, L. Myers, K. Hunkler, T. Flower, and R.E. Kohler, A Novel Multi-lumen Compliant Balloon Catheter Preserves Stem Cell Viability and Decreases Cellular Clumping When Compared to a Standard Single-lumen Balloon Angioplasty Catheter, *Complex Cardiovascular Therapeutics*, Orlando, FL, June 23-27, 2014.

52. J.P. Abraham, The Science of Climate Change (Keynote*), 2014 Summer Institute for Climate Change and Energy Education*, Sandstone, MN, August 4-6, 2014.

53. J.P. Abraham, D. B. Schwalbach, T. M. Shepard, J. M. Gorman, Calculating forces of impact as objects travel from air into water at high velocity, *ANSYS Regional Conference*, Minneapolis, MN, June 10, 2014.

54. B.D. Plourde, D.B. Schwalbach, J.P. Abraham, R.E. Kohler, and N.N. Johnson, Intracoronary Injection of Medication from multi-lumen injection Catheters, *Design of Medical Devices 2014*, April 7-14, Minneapolis, MN.

55. N. Dib, J. Abraham, B.D. Plourde, D.S. Schwalbach, D. Dana, D. Lester, T. Flowers, and R.E. Kohler, Comparison of the Stem Cell Viability and Shear Stress of Single Lumen and Multi

Lumen Balloon Infusion Catheter for Intra-Arterial Stem Cell Infusion, *American Cardiology Conference 2014*, Washington, DC, March 29-31.

56. J.P. Abraham, The Science of Global Warming, What Do We Really Know (Keynote), *Audubon Society National Meeting*, October 6, 2013.

57. J.P. Abraham, Thawing Out Climate Science, IEEE 2013 Awards Banquet, St. Paul, MN, February 23, 2013.

58. J.P. Abraham, Using ANSYS to Model Rotating Oceanographic Devices, *ANSYS Regional Conference*, Minneapolis, June 6, 2013.

59. N. Dib, J.P. Abraham, B. Plourde, D. Schwalbach, D. Dana, L. Myers, T. Flowers, and R. Kohler, Stem Cell Viability Significantly Reduced After Passing Through a Standard Single Lumen Over-the-wire 0.014 inch Balloon Angioplasty Catheter, *TCT 2013 Conference*, October 27-November 1, 2013, San Francisco, CA.

60. J.P. Abraham, Measurements of the Earth's Climate System, *IEEE Conference on Instrumentation and Measurement Technology Conference*, Minneapolis, MN, May 6, 2013.

61. J.P. Abraham, Numerical Simulations of Drug Deposition of Paclitaxel, *Design of Medical Devices Conference*, 2013, Minneapolis, MN, April 8-11, 2013.

62. J.P. Abraham, J. Stark, J. Gorman, E. Sparrow, R. Kohler, A Model of Drug Deposition Within Artery Walls, *Design of Medical Devices Conference*, 2013, Minneapolis, MN, April 8-11, 2013.

63. J.L. Conroy, S.A. Mandia, J.P. Abraham, S.E. Moffitt, G. Tootle, Environmental Litigation and the Role of Climate Scientists, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

64. S.A. Mandia, J. Abraham, J. Dash, M. Ashley, Filling the Knowledge Gap that Exists Between the Public and Its Leaders and Climate Science Experts, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

65. S.A. Mandia, J.P. Abraham, J. Dash, and M. Ashley, Navigating Negative Conversations in Climate Change, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

66. M.J. Kallock, A. Yevzlin, M. Nelson, and J.P. Abraham, Numerical Modeling of Blood Flow in a New Percutaneously Delivered Hemodialysis Shunt, *BMES 2012 Annual Meeting*, Atlanta Georgia, October 24-27, 2012.

67. J.P. Abraham, Understanding Climate Change's Common Myths, *Minnesota Broadcast Meteorologists Climate Change Science Seminar*, St. Paul, MN, October 5-6, 2012.

68. N.P. Sullivan, J.E. Wentz, J.P. Abraham, Multi-Scale Modeling of Tubular Cross-Flow Microfiltration of Metalworking Fluids, *ASME International Mechanical Engineering Congress and Exposition*, Houston, TX, November 9-15, 2012.

69. J.P. Abraham, M. Nelson, J. Jeske, J. Gorman, Simulation Tools for Design and Testing Substitution in Medical Devices, *Lifescience Alley Research Conference, Research and Development 101*, Minneapolis, MN, May 22, 2012.

70. M.J. Kallock, M. E. Nelson, J. P. Abraham, and A. S. Yevzlin, Fluid Mechanic Modeling of a Percutaneously Delivered Vascular Access Device, *American Society of Diagnostic and Interventional Nephrology, 8th Annual Meeting,* New Orleans, LA, February 24-26, 2012.

71. D. Dana, J.P. Abraham, R. Kohler, A. Campbell, B. Baird, M. Olson, and N. Dib, A Novel Catheter Delivery System (CardioDib) That May Enable Intracoronary Stem Cell Infusion by Possibly Minimizing Cellular Clumping and Distal Embolization (DE) While Preserving Cellular Viability, *9th International Symposium on Stem Cell Therapy and Cardiovascular Innovations*, Madrid, Spain, June 7-8, 2012.

72. K.E. Trenberth, K. Emanuel, J.P. Abraham, Climate Science and Meteorology, *AMS National Broadcast Meteorology Conference*, Boston, MA, August 24, 2012

73. J.P. Abraham, J. Jeske, and M. Nelson, Thermal and Fluid Flow Simulations in Health Care: Product Development and Safety Improvement, *Design of Medical Devices Conference*, Minneapolis, MN April 10-12, 2012.

74. J.P. Abraham, Climate Myths, Misconceptions, and Their Creators, American Chemical Society, St. Paul, MN, November 13, 2012.

75. I. Enting, J.P. Abraham, Detailed Debubnking of Denial, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.

76. B.D. Plourde, J.P. Abraham, G.S. Mowry, E.M. Sparrow, Experimental Test of Multi-Stage Vertical-Axis Turbines for Cellular Communication Applications, *ASME 6th International Conference on Energy Sustainability*, San Diego, CA, July 23-26, 2012.

77. M.N. Nelson and J.P. Abraham, Hemodynamics of AV Grafts for Hemodialysis Access, *Design of Medical Devices Conference*, Minneapolis, MN April 10-12, 2012.

78. J.P. Abraham and J.S. Jeske, Cryosurgical Simulations for Ablation of Kidney Tumors, *Design of Medical Devices Conference*, Minneapolis, MN April 10-12, 2012.

79. J.P. Abraham, J.R. Stark, and J.M. Gorman, Drag Calculations on Oceanographic Devices, *ANSYS Regional Conference,* Minneapolis, MN, October 20, 2011.

80. J.P. Abraham, B.D. Plourde, and G.S. Mowry, Fluid Dynamic Simulations of Wind Turbines, *ANSYS Regional Conference,* Minneapolis, MN, October 20, 2011.

81. S.A. Mandia, J.P. Abraham, R. Weymann, and M. Ashley, The Climate Science Rapid Response Team – A Model for Science Communication, *Geological Society of America Annual Meeting and Exposition,* Minneapolis, MN, October 9-12, 2011.

82. S.A. Mandia, J.P. Abraham, R.J. Weymann, and M. Ashley, The Climate Sciences Rapid Response Team – A Model for Science Communication, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

83. J.P. Abraham, J. Stark, J. Gorman, F. Reseghetti, J. Willis, and J. Lyman, Preliminary Fluid Drag Calculations for Expendable Bathythermograph Devices, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

84. S.A. Mandia, J.P. Abraham, R.A. Weymann, and M. Ashley, Scientists Shaping the Discussion, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

85. J.P. Abraham, J.R. Stark, J.M. Gorman, F. Reseghetti, J. Willis, and J. Lyman, Computational Modeling of Probe Dynamics to Improve Ocean Heat Content Measurements, *American Geophysical Union Fall Meeting*, San Francisco, CA December 5-9, 2011.

86. B.M. Osende, J.P. Abraham, and G.S. Mowry, The Design, Installation, and Maintenance of a Village-Sized Solar Power System in Uganda, *Nanotech, Cleantech, Microtech 2011 Conference*, June 13-16, 2011, Boston, MA. Published in the Technical Proceedings of the 2011 NSTI Nanotechnology Conference and Expo, Vol. 3, pp. 755-758, 2011.

87. J.M. Gorman, E.M. Sparrow, G.S. Mowry, and J.P. Abraham, Simulation of Helically Wrapped, Compact Heat Exchangers, ASME 2011 Energy Sustainability *Conference*, Washington, DC, August 7-10, 2011.

88. B.D. Plourde, J.P. Abraham, G.S. Mowry, and W.J. Minkowycz, Vertical-Axis Wind Turbines for Powering Cellular Communication Towers, *Nanotech, Cleantech, Microtech 2011 Conference*, June 13-16, 2011, Boston, MA. *Published in the Technical Proceedings of the 2011 NSTI Nanotechnology Conference and Expo*, Vol. 3, pp. 750-753, 2011.

89. L. Tran, M.P. Hennessey, and J.P. Abraham, Simulation and Visualization of Dynamic Systems: Several Approaches and Comparisons, *ASME International Mechanical Engineering Congress and Expo*, Vancouver, Canada, November 12-18, 2011.

90. J.P. Abraham, Global Warming, What does the Science Tell Us?, *7th Annual Environmental Institute Conference* (KEYNOTE), Minneapolis, MN, April 21, 2010.

91. J.P. Abraham, G.S. Mowry, B.D. Plourde, and W.J. Minkowycz, Numerical Simulations of Vertical-Axis Wind Turbine Blades, *ASME 2011 Energy Sustainability Conference and Fuel Cell Conference*, Washington, DC, August 7-10, 2011.

92. J.P. Abraham, G.S. Mowry, B.D. Plourde, and W.J. Minkowycz, Wind Tunnel Tests of Vertical-Axis Wind Turbine Blades, *ASME 2011 Energy Sustainability Conference and Fuel Cell Conference*, Washington, DC, August 7-10, 2011.

93. R.D. Lovik, E.M. Sparrow, J.P. Abraham, C.L. Zelmer, S.K.S. Friend, and D.K. Smith, Effect of Component Misalignment on Human Tissue Temperatures Associated with Recharging Neuromodulation Devices, *Design of Medical Devices Conference*, Minneapolis, MN April 12-14, 2011.

94. N.N. Johnson, K. L. McCaffrey, K.M. Rose, and J.P. Abraham, Cryosurgical Treatments for Uterine Fibroids, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

95. R.D. Lovik, K. J. Kelly, E.M. Sparrow, and J.P. Abraham, Effect of Misalignment of Implant and Antenna on Heat Generation of Externally Recharged Neuromodulation Implants, *North American Neuromodulation Society 14th Annual Meeting*, Las Vegas, NV, December 2-5, 2010.

96. J.P. Abraham and S. Mandia, An Emerging Ethic of Responsibility: A Case Study for Engaging the Public, *American Geophysical Union Fall Meeting*, San Francisco, CA December 13-17, 2010.

97. J.P. Abraham and G.S. Mowry, B.D. Plourde, Analysis of Thermal and Fluid Flow Problems, *Thermal Packaging and Small Business Innovation Workshop*, Eagan, MN, October 5-6, 2010.

98. N.N. Johnson, J.P. Abraham, Z.I. Helgeson, and M.P. Hennessey, Numerical Simulation of Blood Flow in the Presence of Embolizing Agents, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

99. N.N. Johnson, J.P. Abraham, and Z.I. Helgeson, Calculations of Scald Burns: Effects of Water Temperature, Exposure Duration, and Clothing, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

100. N.N. Johnson, M.P. Hennessey, and J.P. Abraham, Swept Arc Length Measure of Abrasive Wear, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.

101. K.L. McCaffrey, K.M. Rose, and J.P. Abraham, Numerical Simulation of Cryosurgery as a Potential Treatment for Uterine Fibroids, *14th International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

102. J.P. Abraham, E.M. Sparrow, J.C.K. Tong, and W.J. Minkowycz, Intermittent Flow Modeling. Part 1: Hydrodynamic and thermal Modeling of Steady, Intermittent Flows in Constant Area Ducts, *14th International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

103. J.P. Abraham, E.M. Sparrow, J.C.K. Tong, and W.J. Minkowycz, Intermittent Flow Modeling. Part 2: Time-Varying Flows and Flows in Variable Area Ducts, *14th International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

104. K.L. McCaffrey, K.M. Rose, and J.P. Abraham, Cryosurgery as an Alternative Treatment for Menorrhagia and Uterine Fibroids, *ASME Summer Biomedical Engineering Conference*, Naples, FL, June 16-19, 2010.

105. J.M. Gorman, N.K. Sherrill, J.P. Abraham, Analysis of Drag-Reducing Techniques for Olympic Skeleton Helmets, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.

106. B. D. Plourde, J.P. Abraham, G.S. Mowry, Numerical Simulation of Vertical Axis Wind Turbines, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.

107. J.P. Abraham, Z.I. Helgeson, N.N. Johnson, G.S. Mowry, Numerical Simulations and Medical Device Design, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.

108. J.M. Gorman, N.K. Sherrill, J.P. Abraham, Drag-Reducing Vortex Generators and Olympic Skeleton Helmet Design, *ANSYS Users Conference*, Chicago, IL, June 7, 2010.

109. J.P. Abraham, Z.I. Helgeson, N.N. Johnson, G.S. Mowry, (Keynote), Numerical Simulations in Biomedical Design, *ANSYS Users Conference*, Chicago, IL, June 7, 2010.

110. J.P. Abraham, E.M. Sparrow, Y. Bayazit, R.D. Lovik, and D.S. Smith, Numerical and Experimental Simulations as Symbiotic Tools for Solving Complex Bio-Thermal Problems, *Design of Medical Devices Conference*, Minneapolis, MN April 13-15, 2010.

111. E.M. Sparrow and J.P. Abraham, Numerical Solutions of Biological Heat Transfer, *Design of Medical Devices Conference*, Minneapolis, MN April 13-15, 2010.

112. J.P. Abraham, R.D. Lovik, D.S. Smith, E.M. Sparrow, and K.J. Kelly, Heat Generation Measurements of Revised Neuromodeulation Devices and Calculations of Tissue Temperatures, *North American Neuromodulation Society 13th Annual Meeting*, Las Vegas, December 3-6, 2009.

113. J.P. Abraham and E.M. Sparrow, Numerical Simulation as a Tool for Assessing Thermal- and Fluid-Based Processes and Therapies, *Institute for Engineering in Medicine Innovation Showcase*, Minneapolis, MN, September 22, 2009.

114. J.P. Abraham, E.M. Sparrow, and R.D. Lovik, An Investigation of Tissue-Temperature Elevation Caused by Recharging of Transcutaneous Nueromodulation Devices, *31st Annual International Conference of the IEEE Engineering in Medicine in Biology Society*, Minneapolis, MN, September 2-7, 2009.

115. R.D. Lovik, J.P. Abraham, and E.P. Sparrow, Pulasting Fluid Flows Undergoing Transitions Between Laminar, Transitional, and Turbulent Regimes, *ASME 2009 Summer Bioengineering Conference*, Lake Tahoe, CA, June 17-21, 2009.

116. E.M. Sparrow, and J.P. Abraham, Case Studies on the Use of Numerical Simulation for design and Optimization of Medical Devices, *Design of Medical Devices Conference*, Minneapolis, MN April 14-16, 2009.

117. F. Hoover and J. Abraham Assessment of the Carbon Dioxide and Energy Balances of Biofuels, *Climate Change Technology Conference 2009*, Hamilton, Ontario, May 12-15, 2009.

118. J.P. Abraham, G.S. Mowry, and R.E. Erickson, Design and Analysis of a Small-Scale Vertical-Axis Wind Turbine for Rooftop Power Generation, *Climate Change Technology Conference 2009*, Hamilton, Ontario, May 12-15, 2009.

119. F. Hoover and J.P. Abraham, A review: Comprehensive Comparison of Corn-based and Cellulosic-based Ethanol as Biofuel Sources, *Clean Technology Conference and Expo 2009*, Houston, TX, May 3-7, 2009.

120. J.P. Abraham, G.S. Mowry, and R.E. Erickson, Design and Analysis of a Small-Scale Vertical-Axis Wind Turbine, Clean *Technology Conference and Expo 2009*, Houston, TX, May 3-7, 2009.

121. J.P. Abraham, R.D. Lovik, and E.M. Sparrow, Tissue Temperature Rises Due to Heat Generation in Neuromodulation Implants, North American Neuromodulation Society 12th Annual Meeting, Las Vegas, December 4-7, 2008.

122. G. Nelson, A. Majewicz, and J.P. Abraham, Numerical Simulation of Thermal Injury to the Artery Wall During Orbital Atherectomy, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.

123. J.P. Abraham, Integrating Integration of ANSYS/CFX into Classrooms, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.

124. J.P. Abraham, Pressure Drop and Heat Transfer Calculations for Laminar-Turbulent Intermittent Flows, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.

125. J.P. Abraham, J.C.K. Tong, and E.M. Sparrow, Prediction of Laminar-Turbulent Transition and Friction Factors in Transitional Flows, *ASME International Congress and Expo*, Boston, MA, October 31 – November 5, 2008.

126. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Assessment of Possible Thermal Damage of Tissue Due to Atherectomy by Means of a Mechanical Debulking Device, *ASME 2008 Summer Bioengineering Conference*, Marco-Island, FL, June 25-29, 2008.

127. J.P. Abraham and A.P. Thomas, Numerical Simulation of Induced Co-Flow and Laminar-to-Turbulent Transition Associated with Synthetic Jets, *Flucome 2007*, Tallahassee, FL, September 16-19, 2007.

128. J.P. Abraham and C.M. George, An Investigation of Radiation Shields for Full-Building Cooling in Desert Climates, *Solar 2007*, Cleveland, OH July 7-12, 2007.

129. A. Marchese, J.P. Abraham, C.S. Greene, L. Kizenwether, and J. Ochs, Toward a Common Standard Rubric for Evaluating Capstone Design Projects, *National Capstone Design Course Conference*, Boulder, CO June, 13-15, 2007 (Best Paper Award).

130. John Abraham, Chris Greene, Anthony Marchese, External Assessment Through Peer-to-Peer Evaluation of Capstone Projects, *Frontiers in Education*, Milwaukee, WI, October, 10-13, 2007.

131. John Abraham, Computation Fluid Dynamics Using ANSYS CFX, presented at the University of Minnesota Digital Technology Center, Sept. 12 and 14, 2006.

132. John Abraham, Application of the Finite Element Method, *LifeSciences Conference*, Minneapolis, October 5, 2006.

133. John Kim and John Abraham, Design of Experiments in the Medical Device Industry, *LifeSciences Conference*, Minneapolis, October 5, 2006.

134. Ephraim Sparrow, Nick Whitehead, and John Abraham, Fluid Flow Dynamics in the Urinary Tract – Impact on Device Design, Presented to the Department of Urologic Surgery, April 17, 2006.

135. John Abraham, Nick Whitehead, and Ephraim Sparrow, Numerical Simulation of Thermal Therapies, Presented to the Department of Urologic Surgery, April 17, 2006.

136. John Abraham, Nick Whitehead, and Ephraim Sparrow, Biomedical Applications Simulations/Experimental Investigations, *Biomedical Focus 2006*, Brooklyn Center, MN, March 20-21, 2006.

137. Nick Whitehead, Ephraim Sparrow, and John Abraham, A Role for Engineering in Medical Simulations, *Simulation in Healthcare*, Minneapolis, MN, November 28, 2005.

138. Ronald Major and John Abraham, The Application of Thermal Analysis on a Disk Array, *Fluent's 2005 CFD Summit*, Detroit, MI, June 7-8, 2005.

139. Camille George and John Abraham, A Sustainable Low-Energy Cooling System for Hot Dry Climates, *Sustainability as Security*, Austin, TX, October 5-9, 2005.

140. John P. Abraham and Ephraim M. Sparrow, Irrelevance of the Relative Velocity as the Characteristic Velocity When Both a Fluid and its Bounding Surface are in Motion, *Lorenz G. Straub Award*, Minneapolis, MN, November 13, 2004.

141. John P. Abraham and Ephraim M. Sparrow, An Unexpected U-Turn After an Eckert Straight Start, *Eckert Symposium*, Minneapolis, MN, September 13-14, 2004.

142. John P. Abraham and Ephraim M. Sparrow, Methodologies to Enhance the Numerical Simulations of Electronic Cooling, *Semi-Therm Conference,* San Jose, CA, March 9-10, 2004.

143. **Ephraim M. Sparrow, John P. Abraham, and Paul Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, *ASME International Mechanical Engineering Congress and R & D Expo*, Washington, DC, November, 2003.**

144. **J. P. Abraham, Ephraim M. Sparrow, Student-Related Research "Thermal Design Capstone Projects", *ASME International Mechanical Engineering Congress and R & D Expo*, Washington, DC, November, 2003.**

145. Sparrow, E.M., Martin, G.L., Abraham, J.P., and Tong, J.C., Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance. *American Society of Heating, Refrigeration, and Air-Conditioning Engineers Annual Meeting*, Inc., Cincinnati, OH, ASHRAE Symposium Paper, 2001.

146. Tamma, K.K., Zhou, X., Abraham, J., and Anderson, C.V.D.R., Constitutive Model Theories and Plausible Propositions/Challenges to Heat Transport Characterization. *ASME/JSME Joint Thermal Engineering Conference*, March, 1999.

Granted Patents (author of 15 patents)

1. Robert Monson and John Abraham, "Dual-phase thermal electricity generator", U.S. Patent # 8,484,974.

2. Robert Monson and John Abraham, "Variable Orifice Valve", U.S. Patent # 7,559,485

3. Robert Monson, John Abraham, Joseph Crimando, Joel Farley, Matthew Linder, and Joel Seipel, "Vehicle Energy Absorption Apparatus", US Patent # 8,118,255.

4. B.D. Plourde and J.P. Abraham, "Rotor Blade for Vertical Axis Wind Turbine", US Patent # 9,482,204/ WO 2011150171.

5. B.D. Plourde, J.P. Abraham, D.R. Plourde, A. Gikling, R. Pakonen, "Dual-Axis Tracking Device", US Patent # 10,168,412.

6. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Control Valve Assembly for Fluid Heating System", US Patent # 10,495,720.

7. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Dual Axis Tracking Device", China National Intellectual Property Administration, Patent number ZL201580075224.1, 2020.

8. B.R. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Dual Axis Tracking Method", U.S. Patent 10,890,645.

9. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Digital Fluid Heating System", US Patent Application Number 15/818,052, filed November 20, 2017; PCT Application Number US2017/062558, filed November 20, 2017. (Patent granted, number forthcoming).

10. B.D Plourde, J.P. Abraham, D. Plourde, R. Pakonen, A. Gikling, N. Naughton, Fluid Heating system, European Patent, granted, number forthcoming, 2021.

11. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, "Method of Calculating Pathogen Inactivation for a Fluid Heating System", US Patent, 11,255,804.

12. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Digital Fluid Heating System", China National Intellectual Property Administration, Chinese Application Number 201780083752.0

13. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Digital Fluid Heating System", African Regional Intellectual Property Organization (ARIPO), (patent granted, number forthcoming).

14. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Digital Fluid Heating System", European Union Application number JL100643P.EPP (*number to be issued*).

15. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Digital Fluid Heating System", Columbia, Application number NC 2019/00006027, (*number to be issued*).

Pending Patents

1. B.D. Plourde, J.P. Abraham, D. Plourde, R. Pakonen, A. Gikling, N. Naughton, "Fluid Heating System", US Patent Application Number 14/954,292, filed December 1, 2015.

2. B.D. Plourde, J.P. Abraham, "Solar Heating System", US Patent Application No. 62/423,814 (filed November 18, 2016).

3. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Solar Heating for Refrigeration and Fluid Heating Devices", filed March 2018. US Application number 20180266712.

4. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Dual-Axis Tracking Method", US Application number 2019/0107598, filed November 2018.

5. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, "Digital Fluid Heating System", US Application number 2018/0142905, filed November 2017.

Granted Trademarks

1. US Trademark Registration Number 5656322, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.

2. US Trademark Registration Number 5656323, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.

Editorial Board Member

1. International Society of Cardiovascular Translational Research, 2020-present
2. Energies, Thermal Management, 2019-present
3. Cardiovascular Revascularization Medicine, 2018-present
4. Stem Cell Biology and Transplantation, 2015-present
5. Associate Editor, NCSE, Climate Science, 2012-present
6. International Journal of Mechanics and Energy, 2012-present
7. Open Mechanical Engineering Journal, 2007-present
8. Open Mechanical Engineering Reviews, 2007-present
9. Open Mechanical Engineering Letters, 2007-present
10. Open Medical Devices Journal, 2008-present
11. Creative Engineering Journal, 2009-present

12. ISRN Applied Mathematics, 2011-present
13. International Journal of Sustainable Energy, 2012 - present
14. International Journal of Materials, Methods, and Technologies, 2012- present

CONSULTANTSHIPS

GRANTS (funding $4.0 million)

HRST, Inc., MN	**2021**
Biotronik	**2021**
Starky	**2020**
Marvin Windows	**2020-2022**
Cardiovascular Systems, Inc.	**2019-2021**
ALS Consulting	**2019**
Medivators	**2018-2019**
Medivators, MN	**2014-2015**
EKOS, MN	**2018**
Marcor	**2018**
Marvin Windows	**2018**
Medtronic, Fridley, MN	**2017-2020**
Orbital ATK	**2017-2018**
Pride Engineering, MN	**2017-2018**
Cargill, MN	**2016-2017**
EKOS, MN	**2016-2017**
Precision Air, MN	**2016**
3M, MN	**2015-2017**
Flourescence, Inc., MN	**2015**
Smiths Medical, MN	**2014-2015**
WTS LLC, MN	**2014-2022**
Somnetics, MN	**2014**
Lake Region Medical, MN	**2013-2014**

Amphora Medical, MN	**2013-2014**
ALS Consulting, MN	**2013-2016**
Medtronic, Fridley, MN	**2013-2016**
Devicix, MN	**2012-2013**
CriticCare, MN	**2012**
HRST, Inc., MN	**2012-2015**
QIG Group, OH	**2011-2013**
Phraxis, MN	**2011-2012**
Cardiovascular Systems, Inc., Roseville, MN	**2007-2015**
Translational Biologic Infusion, AZ	**2011-2013**
Galil Medical, Roseville, MN	**2011**
Imation, Oakdale, MN	**2010**
Medtronic, Fridley, MN	**2008-2011**
R4 Engineering, India	**2008-2009**
Horizontal Winds,	**2008-2009**
Lockheed Martin, Eagan, MN	**2007-2009**
St. Jude Medical, Minnetonka, MN	**2007-2009**
Arizant Medical, Eden Prairie, MN	**2006**
Johnson and Johnson, Newark, NJ	**2004-2005**
Cortron/XeteX, Fridley, MN	**2005**
MicroControl Company, MN	**circa 2001**
Donaldson Co., Bloomington, MN	**1999-2003**
Augustine Medical, Eden Prairie, MN	**2000-2003**
Midmac Systems Inc., St Paul, MN	**2002**
Remmele Engineering Inc., St Paul, MN	**2002-2005**
Urologix, Minneapolis, MN	**circa 2004**
Restore Medical, Minneapolis, MN	**circa 2002**
Caterpillar, Minneapolis, MN	**circa 2000**

ADC telecom, Minneapolis, MN **circa 2000**

Entropy Solutions **circa 2000**

XeteX, Inc., Minneapolis, MN **1996-2000**

Pneuseal, St. Paul, MN **1996-1998**

Los Alamos National Laboratory, Los Alamos, NM **1994**

GRANTS (funding $4.0 million)

HRST, Inc. **2021**

$34,000 for analysis of flow patterns in power plants

Biotronik **2021**

$44k for simulation of heating caused by implanted medical devices

Flotherm (SBIR award FAIN 2034065) **2020-2021**

$48k for simulation of body-heating devices

SBIR funding, NSF Small Business Innovative Research project

Starky **2019-2020**

$6k for thermal modeling of hearing aid batteries

National Science Foundation (Co-PI, FAIN = 2018403) **2020-2021**

$424k for engineering PIV instrumentation

Intertek **2019-2020**

$13k for study of tissue surrogates for biological heating

Cardiovascular Systems, Inc. **2019-2021**

$13k for thermal model of blower impellor for a dialysis pump

$9k for thermal model of blower impellor for a dialysis pump

$4k for thermal model of blower impellor for a dialysis pump

$20k for flow model of blower impellor for a dialysis pump

$5k for flow model of blower impellor for a dialysis pump

ALS Consulting **2019**

$15k for thermal model of power plant

Medivators **2019**

$12k for thermal model of thermal sterilization

Marvin Windows **2019-2022**

$4k for thermal analysis of a tiny home

$5k for thermal model of manufacturing line

$4k for thermal model of manufacturing line

Medtronic **2019**

$22k for simulation of tissue temperatures during transcutaneous recharge

$25.5k for simulation of tissue temperatures during transcutaneous recharge

Medivators **2018**

$18k to research airflow in medical sterilization equipment.

Marvin Windows **2018-2020**

$6k to research thermal processes during window ventillation

$4k to research thermal processes of natural lighting

$4k to research thermal processes of natural lighting

Medtronic **2018**

$3k to research battery heating rates

$8k to research thermal tolerance of brain tissue

EKOS **2018**

$14k for analysis of flow distribution within stents

Marcor **2018**

$10k for fluid and heat transfer analysis

Pride Engineering **2017**

$3k to calculate a metal stamping machine process

Orbital ATK **2017-2018**

$30k to simulate fluid flow

$12k to simulate fluid flow

Medtronic **2017**

$5k to research thermal tolerance of brain tissue

$14k to calculate cranial temperature increases during transcranial recharge

3M **2017**

$14k to simulate airflow in ultra-clean operating rooms.

Zoll Engineering **2017**

$5.5k for design of flow through a ventilation medical device

Cargill **2016-2017**

$14k for analysis of food frier

$15k for analysis of a food processing device

EKOS **2017**

$14k for analysis of flow distribution within stents

$14k for analysis of flow distribution within stents

$12k for analysis of flow distribution within stents

ALS Consulting **2016**

$15k for analysis of fluid flow in power plants

Precision Air **2016**

$1600 for simulation of airflow in operating rooms

Medtronic **2016**

$12k for simulation of tissue temperatures during transcutaneous recharge

3M **2015**

$12k to simulate airflow in ultra-clean operating rooms.

Cardiovascular Systems, Inc. **2015-2016**

$8,000 for the study of deformable arteries

$6,000 for biological flows and impellor design

AF Energy **2015**

$3000 wind turbine calculations

Intellectual Ventures Laboratory **2015**

$2000 wall condensation calculations

Medivators **2015**

$4000 for flow and pressure calculations medical chamber.

Floursecence, Inc. **2015**

$2,000 designing biological heater for cell environments

Mador Technologies **2015**

$20,000 analyzing a liquid nitrogen water condensation device

Koronis Biomedical Technologies **2015**

$5,000 simulation of fluid flow

Mador Technologies **2014-2015**

$8,000 analyzing a liquid nitrogen water condensation device

National Resources Defense Council **2015**

$10k for climate education work

Medtronic **2014**

$12k for simulation of tissue temperatures during transcutaneous recharge

Smiths Medical **2014**

$9.5k for design and optimization of medical warming blankets

$10k for the design and improvement of medical fans

$12kfor the design and analysis of human thermal analogs

WTS LLC **2014-present**

$1.5m for the design of solar pasteurization systems

Medivators **2014**

$4000 for flow and pressure calculations medical chamber.

$3000 for flow and pressure calculations medical chamber.

Somnetics **2014**

$6000 for flow and pressure calculations in CPAP devices.

Lake Region Medical **2013-2014**

$4500 for simulations of a guidewire manufacturing oven

Amphora Medical **2013-2014**

$55.5k for design of RF probes for ablation of bladder tissue

ALS Consulting **2013-2014**

$17.5k for analysis of fluid flow in power plants

Medtronic, Inc. **2012-2013**

$13k for analysis of subdermal heating associated with recharge of neuromodulation systems.

Phraxis **2013**

$2,250 for the analysis of blood flow through an AV shunt

Translational Biologic Infusion Catheter **2011-2013**

$21.5k for the study of flow and pressure drop in a stem-cell delivery catheter

Advanced Circulatory Systems, Inc. **2013**

$4200 for fluid flow modeling of medical-device blowers

HRST, Inc. **2012-2015**

$11,250 for analysis of flow patterns in manifolds

Devicix **2012**

$2000 for the analysis of medical-fluid injection devices

Helical **2012-2013**

$18,200 for the design and analysis of rooftop wind turbines

QiG Group **2012**

$7000 for study of thermoelectric technologies to power implants

HRST, Inc. **2012**

$4300 for analysis of perforated plates for flow uniformity

Energy Foundation **2012-2013**

$30k developing climate-science communication strategies

CriticCare **2012**

$4,275 for numerical modeling of accelerated aging of medical devices.

HRST, Inc. **2012**

$5,540 for research study on mixing efficiency in heat recovery plants.

Windstrip, LLC **2009-2013**

$1m for development of vertical axis wind turbines to power cellular communiation equipment.

QiG Group **2011-2012**

$20k for study of implant heating of biological tissue

Phraxis **2011-2012**

$8,000 for the analysis of blood flow through an AV shunt

Energy Foundation **2011-2012**

$71k developing climate-science communication strategies

Cardiovascular Systems, Inc. **2011**

$23k for the study of paclitaxel distribution techniques.

Cardiovascular Systems, Inc. **2011**

$5,000 for the study of temperature management in palleted products

Galil Medical **2011**

$9,000 for the kidney tumor cryosurgical devices.

Multiple groups **2010**

$13,000 for installation of solar panels in Uganda

Imation

$10k for the design of a polymeric extrusion die **2010**

Cypress Wind

$30.6k for the development of a vertical axis, small-footprint wind turbine. **2010**

Cypress Wind

$27k for the development of a vertical axis, small-foorprint wind turbine. **2009**

Cardiovascular Systems, Inc. **2009**

$80k for the study of cavitation and bolus formation during orbital atherectomy procedures.

Medtronic, Inc.

$65k for analysis of subdermal heating associated with recharge of neuromodulation systems. **2008-2011**

University of St. Thomas Faculty Development Grant **2009**

$4,200 for the purchase of a high-performance computer for numerical simulations.

CSUMS: A computational Traininig and Interdisciplinary Research Program for Undergraduates in the Mathematical Sciences at the University of St. Thomas **2008-2013**

Served as Senior Personnel on a $716,836 NSF award for the development of applied research projects for undergraduates in mathematics.

Lockheed Martin Innovative Program - Advanced Cooling Technology grant **2009**

$19.5k for the improvements to avionics heat pipe applications.

Horizontal Winds **2008-2009**

$11k for research on vertical-axis wind turbines

R4 Engineering **2008-2009**

$10k for analysis of building-support insulation systems

Lockheed Martin Innovative Program - Advanced Cooling Technology grant **2007**

$53k for the development of advanced electronic-cooling methodologies.

Arizant Medical **2006**

Characterization of a forced-air patient warming device

Johnson and Johnson, Newark, NJ **2004-2005**

Analysis of a uterine fibroid embolization device

Urologix **circa 2004**

Design of thermoelectric device for heating/cooling of urological catheter fluids

Donaldson Co. **1999-2003**

Analysis and characterization of a filter-manufacturing device

Augustine Medical **2000-2003**

Characterization of a forced-air patient warming device

Midmac Systems Inc. **2002**

Thermal analysiss of a polymeric sealing machine

Restore Medical **circa 2002**

Characterization of sleep apnea treatment

Remmele Engineering Inc. **2002-2005**

Thermal analysis of a polymeric sealing machine for insulin packaging

Thermal analysis of liquid-based cold plates for cooling naval radar

MicroControl Company **Circa 2001**

Analysis of burn-in board devices

Caterpillar **circa 2000**

Analysis of a screed heating machine

ADC Telecom **circa 2000**

Optimization of an AC/DC power converter

Entropy Solutions **circa 2000**

Design and Analysis of insulation and phase change thermal management for shipping containers

XeteX, Inc **1996-2000**

Design of an air-to-air heat exchanger

Creation of a film processing machine for coating heat exchangers

Construction and operation of a full-sized HVAC test facility

Pneuseal **1996-1998**

Operation and optimization of a polymeric sealing device for medical packageing

Principal Investigator – Supercomputing Institute **2002-2012**

Served as PI for multi-year project dedicated to performing computational fluid dynamic studies. This grant awarded computing resources at the Supercomputing Institute for Digital Simulation and Advanced Computing.

Principal Investigator – ASHRAE Project Grant Program **2003**

Awarded a $5,000 grant funded by ASHRAE to investigate the efficacy of rotating-wheel heat and moisture exchangers.

Faculty Advisor – Bush Grant, Young Scholars Program **2002**

Faculty advisor for a $3,000 grant for undergraduate research of air-jet heat transfer for surgical applications.

Faculty Advisor – Bush Grant, Young Scholars Program **2002**

Faculty advisor for a $3,000 grant for undergraduate research to encourage American Indian students to pursue careers in science and technology.

A Multi-Function Heat Exchanger for Control of Temperature, Moisture,

and Air Quality **1997-2000**

Project Engineer for $475K SBIR grants awarded by NSF, grant nos. 9660900

and 9801062

Exhibit B (Testimony in the Past Four Years)

Gareis v. 3M Company, 16-cv-4187

City of Wyoming, Minnesota, et al., v. Kimberly-Clark Corp. and Rockline Industries,

AOS Holding Company v. Bradford White Corporation (C.A. 18-412-LPS-CJB)

American National Manufacturing v. Sleep Number Corporation
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Medline Industries, Inc. v. CR Bard, Inc. (Civil action 1:16-cv-3529)
Medline Industries, Inc. v. CR Bard, Inc. (Civil action 1:16-cv-07216)
Medline Industries, Inc. v. CR Bard, Inc. (Civil action 1:14-cv-03618)

Commonwealth of Pennsylvania v Bernard Laquain Jackson (CR-128-2019)

Fisher and Paykel Healthcare Limited v. Flexicare

Intex v. Bestway Inc.

M.E. Mann v. Competitive Enterprise Institute and National Review Journal

Cochran v. Leigh Barrell et al., (No. 16C04224-1)

Frymaster LLC etr al v. Sherwood Sensing Solutions LLC

RAI Strategic Holdings, Inc. v. Altria Client Services LLC
(no. 1:20-cv-393, E. Va.)

Han Jia and Dan Wu v. King County Public Hospital

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Asetek Danmark v. CoolIT Systems, Inc. and Corsair Memory, Inc.

George T. Monyota v. Rajesh Sharma, Advanced Heart and Vein Center, Anna Landry
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